LECTURES, REPORTS,

LETTERS, AND PAPERS

ON

SANITARY QUESTIONS.

BY

ROBERT RAWLINSON, ESQ., C.B., F.G.S.,

CIVIL ENGINEER.

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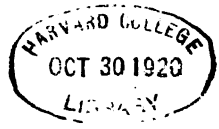

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TO

EDWIN CHADWICK, Esq., C.B.,

AS THE

CHIEF PROMOTER

OF

MODERN SANITARY WORKS AND APPLIANCES

BY

THE AUTHOR.

London, 1876.

SANITARY ENGINEERING.

A LECTURE ON METEOROLOGY delivered in the month of November, 1868, before the Royal Engineers, at their Establishment, Chatham.

In the construction of many important works, engineers find that they have to contend with much hostile action of the elements; consequently it is absolutely necessary that the technical education of engineers should include a study of Meteorology—the science which (in addition to other phenomena) treats of the evolution of heat and moisture, of evaporation and condensation, of tornadoes and calms, of wind and rain, of ocean waves, river currents, land absorption, and land floods.

For the purposes of this lecture, it appears desirable to omit detailed notices of abtruse meteorological questions concerning the origin of storms and electric phenomena, such as the formation of cumulous clouds, hail, tornadoes, and water-spouts. Considerations such as these, which are powerfully affected both by general causes and by local influences; would, on the present occasion, have a tendency rather to bewilder than to give information. To certain specific facts connected with the science of Meteorology, as applicable to works of water supply and drainage, this introductory lecture will, therefore, be devoted; and these facts will be set forth in simple language; my purpose being to lead you onwards, from first principles and elementary facts, to those conclusions which eventually I shall place before you.

This earth consists, on its surface, of ocean and dry land, the relative areas of the two being about in proportion of 7 to 3. Assuming, therefore, the entire surface of the earth to be 200 millions of square miles, then the ocean has an area of about 140 millions of square miles, leaving an area of about 60 millions of square miles to the dry land.

Thus constituted at its surface, the terrestrial globe is enveloped with an atmosphere composed of oxygen and nitrogen gases, nearly in the proportion of two atoms of the latter gas to one of the

former; and, in combination with these two gases there also exists a fractional per centage of carbonic acid gas. In this atmosphere water is present in the form of vapour.*

The one main source of heat to the surface of the earth and atmosphere, and of electric action, is the sun. By the action of the sun, also, is produced all those phenomena of Meteorology which we have to consider.

That great reservoir of water, the salt ocean, is the prime source of all "fresh water," wherever and however it may be present, either upon the surface of the land, or within the stratafied crust of the globe. And it is through the process of evaporation that all "sweet" or "fresh water" is obtained from the salt waters of the ocean.

If the heat emitted from the sun were, year by year, uniformly the same, there would, necessarily, be uniformity of evaporation; and this would imply a corresponding annual uniformity in precipitation of vapour in the form of dew, snow, hail, or rain. On the other hand, the reverse of these statements will be equally true: that is to say, irregularity in the emission of heat from the sun must be attended with a corresponding irregularity in the volume of ocean-water evaporated, which last irregularity must also in the same degree affect the volume of fresh water obtained by precipitation. Whether the heat of the sun, year by year, be uniform, or whether it is subject to fluctuating variations, it may be assumed as certain, that the heat-giving action only varies within certain limits, and so conforms to every other known operation of nature; for we observe the grand phenomena of the elements obeying a law which, out of apparent irregularity and inequality, brings forth equality and order, just as a pendulum ever beats true time in its swing, however great or however slight may be its motion; such variety pervades nature's working, and such is the type of variety in the transmission of solar heat to this earth; that so, in a series of years, an average temperature is determinable, to which may be referred all those complex and wonderful changes that are perpetually taking place on the surface of the globe.

The leading facts to be recognised by engineers are consequently these: there is evaporation from the ocean caused by the heat of the sun; and in proportion to this heat is the volume of water that in each year is evaporated; this vapour, whatever its volume carried into the atmosphere, must again be precipitated in the form of fresh-water. These grand evolutions of the elements can be brought under no control by human power.

Experience has demonstrated that in different countries and climates the annual volume of rain which falls is subject to con-

* The permanent gases of the atmosphere are nitrogen, oxygen, and carbonic acid. The first two are always found in nearly unvarying proportion of 80 per cent. of nitrogen and 20 per cent. of oxygen, with carbonic acid in a fractional proportion—from 3·7 to 6·2 in 10,000 parts.

siderable variations. In the equatorial regions, for example, where the sun's heat is greatest and most powerful, evaporation is necessarily most copious and the rainfall is heaviest; and, as we approach either pole, with decreasing solar heat evaporation decreases and the rainfall is in a proportionately diminished volume. But in no region of the earth's surface does evaporation cease. Vary as it may, evaporation is general and constant. It takes place incessantly, wherever the ocean extends. Even icebergs and the broad floes of the polar oceans evaporate. In tropical regions, as well as in the colder zones of the earth's surface, vapour is constantly passing into the atmosphere, again to be condensed and become fresh-water; and at all temperatures (boiling or freezing) this act of evaporating water implies the absorption of *latent* heat, which heat is again given out, sometimes accompanied by lightning and thunder, when invisible vapour is condensed into water, as tornado, water-spouts, deluging sheets of water, gentle rain, snow or hail.

The fall of rain is determined by the amount of invisible vapour which is carried up into the atmosphere, as also by terrestrial causes, such as latitude, the relative position of land and water, plains, valleys, mountains, and air-currents (winds) which all act and re-act upon the process of precipitating vapour into rain. This may be illustrated simply by what takes place year-by-year in our own country. In England the annual average fall of rain is from 30 to 36 inches. The distribution of this rainfall is, however, singularly arbitrary, as the average fall of rain in one portion of the Lake districts is not less than 150 inches in each year; and even 300 inches of rainfall has been experienced at Styehead. In contrast with this, on a portion of the eastern coast of England the average yearly fall of rain does not exceed 20 inches; and, in a dry season, it sinks down to 14 inches. In the Thames valley, the average yearly fall is 27 inches. On the western coast of England, as also on the southern, the rain which regularly falls year by year considerably exceeds in volume the rainfall on the eastern coast. This result is produced by a greater local prevalence of the south-west wind, which brings in the vapour-laden atmosphere from the Atlantic Ocean, and much of this vapour, as it sweeps towards and over the backbone ridge of our island, becomes condensed, and precipitates heavy rains in the districts that lie towards the south and the west.

During the actual descent of the heaviest rain over any area of fall, the process of evaporation is maintained. Recent researches have led to the discovery that, in England, the amount of constant evaporation is greater than previously had been supposed. [There do not appear to exist any certain data which may be accepted as determining accurately the comparative amount of evaporation in the tropics.] But, if we take the valley of the Thames, which contains an area of about 5,000 square miles, and where the yearly average rainfall amounts to 27 inches, we find something nearly approaching to two-thirds of the entire fall of rain re-evaporates and passes again, in the condition of invisible vapour, into the atmosphere.

That is to say, about two-thirds of the entire volume of the rain that falls upon the area of the Thames valley, and is there measured in the rain-gauge, is not measurable in the river or in any of its numerous springs and feeders; nor could this large proportion of the whole yearly rainfall be admitted by an engineer into his calculations for any works to be constructed by him for water-supply in the valley of the Thames. He could really rely only upon one-third of the measured rainfall, and of that third one-half now passes away in floods, and the other half by perennial river flow. Once more: take the valley of the Lee, a tributary of the Thames, having an area of 500 square miles. Four-fifths of the rain-fall is not measurable to the river—a fact which has been determined by accurate gaugings taken during the last twenty years. It has been demonstrated that four-fifths of this rainfall passes away through re-evaporation.

I now desire to direct your attention to some important considerations in connection with "averages." In questions of water-supply engineers have been in the habit of considering that they have to deal with averages. It is necessary that you should distinctly understand when and how averages are liable to be fallacious. An average is useful when an appeal is made to it to indicate the *general* difference that exists between one district and another district. But if averages of annual rainfalls in any particular locality, for however long a period taken, are accepted and adopted as giving the true basis upon which either sewers or works for providing a water-supply should be projected, subsequent experimental test of use and supply would be certain to show that the engineering works had been designed and built upon misleading data. The engineer, in such a case, would find that the averages to which he had trusted had misled him. This arises from the fact that his averages had made no provision for encountering and dealing with exceptional circumstances and *occasional excesses*—excesses, probably, which may occur only at long intervals, but which, when they do occur, may be both sudden in their appearance and violent in their operation. Averages extending over a period of one hundred or more years would be required, in order to secure their including and accounting for occasional excess; and even then an average would fail to indicate the amount of precaution that would be required to meet and provide against maximum excesses.

The average fall of rain for the entire surface of the earth may be assumed at 150 inches; and if we apply the rule of ⅓ less for a dry season, and ⅓ more for a wet season, the dry season would give 100 inches, and the wet season 200 inches. If any such variation can be even approximately settled, we may then conclude that there is a corresponding annual variation in the heat and evaporating power of the sun.

Some districts of the earth's surface are rainless, and other districts are exceptionally wet. Some mountain ranges are so lofty as to prevent vapour passing over, whilst all ranges and

groups of mountains act as condensers, some precipitating atmospheric vapour in almost unceasing rain. Africa presents examples in the Great Desert for drought, and at the sources of the Nile for rain.

I must here advert to another fact that bears upon our inquiry at the present point. I constantly hear assertions to the effect that *something* has taken place in the course of events in inhabited districts, which has caused an alteration in the character of the seasons. It is certainly true that man modifies climate over tracts that have been cultivated; but it is asserted, further, that in various parts of the world, through cutting down forests, and in consequence of certain other operations, the works of man, climate has been so far modified as to have had its character absolutely changed —"The Thames is not now frozen over as in times past," one place has more rain than formerly, another place less, and so on. If, by assertions such as these, it is intended to be implied that any works of human hands have actually altered the current course of nature, I must meet such allegation with a positive denial. The most stupendous of human works can effect only the comparatively small and narrow space of the earth's surface upon which they may have been executed. Evaporation has only an indirect and incidental reference to the land—its real dependence being on the great ocean, and the greater sun. And so, while man may exert an influence upon climate over the little area of his operations, his works can avail nothing to affect the grand features of nature even over that small area, or to disturb the majestic scale on which she accomplishes her purposes. Cosmical Meteorology is unaffected, and must continue to be unaffected, by human agency. The powers of man can never seriously modify the heat of the sun, cloud, rain, nor climate, as these have reference to the world at large. All statements, therefore, which would assign cosmical atmospheric effects to the cutting down of forests, to land drainage, land cultivation, and such like agencies, must be treated with practical disregard. The climate of the world is not altered, cannot be altered by its human inhabitants. Floods and droughts will continue to occur in time to come, as they have occurred in time past; and it will also be precisely the same with other natural phenomena; these are incidents for which the engineer must make provision, as they are certain to recur, the conditions of their recurrence and the periods alone remaining uncertain; and as such the engineer must regard them. Indeed, he must learn to comprehend the elements in their wildest moods, and be prepared to encounter them when in such moods as at once his duty and his privilege. Hence, when an engineer finds himself placed in some new country where he is required to erect works, if it should be possible for him to ascertain that in that country, at certain periods of the past, the elements had exhibited strange and anomalous excesses, he may rest assured, unless some cosmical change has intervened, that no decided and permanent modification of climate has been produced which has had power to prevent the recurrence of excesses. If there have been devastating floods, similar

excesses must be prepared for; or engineering works built in disregard of such warnings may not be competent to withstand meteorological excesses, and will be liable to serious damage: such works may even be swept away before the eyes of their constructors. About two years ago this truth was exemplified under my own observation, in a remarkable manner. At that time I was instituting official inquiries concerning the pollution of rivers in the West Riding of Yorkshire. Persons who appeared before me for the purpose of giving evidence connected with the inquiry, were questioned on these points, and were unanimous in rejecting the idea of there occurring any such floods in those rivers as had occurred forty or fifty years before. They were positive, in their evidence, that no such incidents could possibly ever take place again; and the reason for so decided a conviction they declared to rest on the changes that had (as they considered) been wrought in their climate by drainage and cultivation. Before my inquiry had, however, been brought to its close, while I was sitting at Halifax, heavy rain commenced, which continued for two days, and it proved to be as serious in its effects as any of its predecessors. The whole range of the valleys of the Aire and Calder was flooded; streets in towns were laid deep under water, mills and houses were inundated, bridges, and one large viaduct, were washed down, cattle were drowned in their pastures, and human lives were also sacrificed; the losses inflicted upon property in the district, arising out of this two days' rain, being variously estimated to amount to from half a million to a million sterling. Here was a startling practical comment upon the popular theory, that climate and rainfall had been subjected to fresh conditions because of land-draining and cultivation.

While thus the truth remains that, on a grand scale, man is powerless to affect the elements, observant care and forethought may accomplish much to protect property from such injuries as are occasioned by sudden but natural occurrences. Had the local authorities been careful not to obstruct and ill-use the streams, and had they as carefully avoided the erection of various structures by which the free course of flood-waters was impeded, the property in the valleys of the Aire and Calder might have been saved from the most serious consequences of the sudden heavy rainfall to which I have just adverted. In one great establishment in the Calder valley, where the flood-waters had risen four feet above the mill-floors, and had submerged carding-engines, looms, weft, warp and cloth, I was informed by the proprietor that this was the fourth occasion of the recurrence of a similar catastrophe. And yet nothing had been done, and apparently no effectual course of action was in contemplation which might anticipate another flood, and prevent a fifth destruction of a similar character.

It is not my intention to introduce into this lecture any tables, because books of tables—such, for example, as Beardmore's—are ready at hand for reference; but, instead of tables, I shall state the results of my own observation and experience. Records of rainfall

are obtainable, for Great Britain, the Continent of Europe generally, parts of India, China, Africa, and Australia; for New Zealand, North and South America, and many islands. In all these documents annual variations will be found to have been recorded; and in all there are dry seasons, and there are wet seasons. Parts of India have been deluged with rain, while other parts have been burnt up with dry heat. America, or parts of America, have been wet, when Europe, or a part of Europe, was dry; and so, in like manner, it has been in other places and in other countries. There is no such occurrence as any season being either wet or dry over the whole surface of the globe.

The annual variation in falls of rain, generally prevalent, appears to be about as 1 to 2. That is, in one year, the rainfall may be 20 inches or 40 inches, and in the next year it may amount to 40 inches or 80 inches; hence averages of 30 inches and of 60 inches result. Now, in any new district which may claim your attention (unless local facts establish other conclusions), when you have obtained tables of the recorded averages of rainfall extending over a series of years, if you deduct one-third from these averages it will give the driest year, and if one-third be added it will give the wettest year. Thus, in the Thames valley, with an average rainfall of 30 inches, the fall in any very dry year may be estimated at 20 inches, and in any very wet year at 40 inches. This calculation gives a rough workable average. At the same time, it is most important to take into consideration probable excesses, in either direction, above or below any minimum or maximum. In the construction of waterworks, when the engineer has to rely on water which he has to gather from the earth's surface, he must ascertain both the maximum and the minimum volume of such supply; for the elements will assuredly bring him to the test of that minimum as well as of that maximum. Nature does not give wet and dry seasons in accordance with any fixed law; but it may be now as in the days of Pharaoh, seven dry years may follow in uninterrupted succession. In India, where the professional services of the Royal Engineers are called into action, excessive variations of rainfall are but too well known. There, also, where human life is so prolific, the means of sustaining that life (if there are no stores of water and means to use it) depend directly upon the amount of rain that falls; and also, in some degree, upon the regularity of its falling. Hence has arisen the imperative necessity for devising works of irrigation based on strictly correct principles, of which some have been carried out on a grand scale, while others of equal magnitude have been projected. Since dry seasons invalidate averages, engineers who may work in India must keep in view the fact; and I desire to direct your particular attention to two other circumstances arising out of diminished rainfall, which will seriously affect the volume of water that the engineer might expect to have at his disposal. These are—first, an increase of heat, the result of a diminished rainfall; and, secondly, in consequence of this increased heat, a greater proportionate

amount of evaporation from the heated surface of the earth. Thus, a diminished rainfall in such a country as India acts directly in causing an increased diminution of water; and engineers, consequently, must be prepared to experience droughts reduced in a much greater degree than two-thirds of any average fall of rain.

In England, from 2 to 5 inches of rain is the ordinary month's fall; and, as a general rule, such falls are sufficient to feed our rivers, streams, and springs; but in the course of last summer (that of 1868) a fall of 2 inches in seven days descended at such intervals upon the heated ground, that the whole volume of water was forthwith again evaporated, without having left any flow whatever to touch any waterworks. Similar causes would produce similar results, but under a far graver aspect, in India.

When about to form plans for waterworks, engineers will consider that they have to take into their calculations the elements, the physical aspect of the country, the substrata and the surface area with which they have to deal, and the amount of reservoir storage that must be provided. And here I must add another word of caution, lest any engineer should be deceived by averages. The minimum supply is the one only true and reliable authority, as this determines what volume of water may be obtained in very dry seasons. Such a guide as this, therefore, unlike ordinary averages, will send the engineer further afield than otherwise he would have gone, will cause him to enlarge the scale of his works, and induce him to be prepared to store up more abundant supplies.

The aqueous vapour which forms rain, itself depending upon evaporation caused by the sun, is accumulated in clouds. These clouds drift away with the different currents of the atmosphere; and in their course may discharge a portion only of their rain upon the land, much of it falling from them back again into the ocean. Now, rain that falls from the clouds does not represent the area of the ocean's surface from which the water has been evaporated; consequently, in particular seasons, in accordance with the nature of atmospheric currents by which the clouds are carried away, a great accession of wet may take place in some one district, and some one country, coincident with a great drought in other much larger districts and other countries. This is what took place under our own immediate observation the last season, which certainly will be remembered by meteorologists as a summer of extreme contrasts. In England, as also throughout the greater part of Europe, the spring and summer seasons having been exceptionally hot and dry; but in other parts of Europe, in many parts of India also, and of America, this same spring and summer has been cold cloudy, and exceptionally stormy and wet. These phenomena may be traced to a tendency which exists in nature to repeat excesses through a certain cycle. For example, if, from any special cause, the wind and clouds set in over any particular region where condensation and precipitation commence, these operations have a tendency to attract vapour from all sides to the same area, and to

repeat the condensation there until a change is brought about either through a process of exhaustion, or in consequence of the more powerful antagonistic action of some other natural agency.

The average volume of rainfall in England I have already stated to be about 36 inches. In some parts of India the average is as high as 300 inches; and this fall takes place during the monsoons, which occupy about three months in the year. The actual full weight of the entire volume of the rain, however, falls within a single month. During the last year, in some parts of Bengal 135 inches of rain fell in twenty-four days. This was in the month of June, on the 21st day of which month 16·4 inches of rain fell. In Bombay the lower parts of the town were flooded to the depth of 4 or 5 feet; so that, even if there had existed main sewers as large as railway tunnels, they would have been filled without materially lessening the surface water. Such sudden and violent excesses of rainfall, it must be observed, are not exclusively restricted to the tropics. They occur also in our own country, notwithstanding the comparative smallness of our yearly average. We have just seen how, in Bengal, on the 21st of June last, there was a rainfall of 16·4 inches. This fall occurred within the space of the twenty-four hours of a single day; but in England, during a thunderstorm, as much as 2, 3, or even 4 inches of rain have been known to fall in a single hour. In the consideration of this question of rainfall, for all practical purposes of engineering, there exists the truly terrible contingency of a sweeping destruction being brought about by a sudden storm, unless engineers extend their calculations beyond averages to maximum excesses. And, from the neglect of such calculations, most serious mistakes have been made in modern engineering, in our own country, in Europe generally, in the East, in Africa, and in Australia. In the wet season, in Yorkshire, to which I have already referred (November, 1866), two days' and nights' rain swept down a large masonry viaduct, belonging to the Midland Railway, which could not have been erected at a cost of much less than £20,000 or £30,000. When this viaduct was constructed, the engineer had not contemplated, as a possible contingency, that the small river which flowed through a wide valley might swell into a devastating torrent; and, consequently, when the great storm came, his foundations were under-cut, and the whole viaduct became a heap of ruins. In other parts of the world, and particularly within the tropics, engineers have to contend with floods of a much heavier and more destructive character than the worst that have been known to occur here. In England, some of our rivers—as the Eden at Carlisle, the Ouse at York, and the Thames in its upper branches—rise, from their dry water-bed to their flood-water height, 20 feet vertical; but in South Africa the rise of rivers is not less than 60 or 70 feet. In Australia, some rivers have actually risen 120 feet; in Italy, and in Spain, roaring torrents rush furiously along where, in the previous year, there existed only dry ravines. We have all lately learned that similar

excessive changes from dry valleys to the beds of sweeping torrents occur in Abyssinia. If engineers desire to construct works that will prove safe and enduring, these excesses must be taken into their calculations. Meteorology, indeed, is to engineers a study of infinite value and importance, one that is absolutely necessary.

Whether local written records of heavy and exceptional floods be or be not obtainable by engineers for their instruction and guidance in new countries or districts in which they may have to construct works, or to direct military or other operations; it is always an important part of an engineer's duty to examine and study with care the physical aspect of the scene of his future action, with a view to ascertain what Nature herself may have recorded, after an expressive and significant fashion peculiar to herself, concerning her own operations. Nature rarely fails to write her own history, either of uninterrupted quietude, or of occasional floods, on the sides of mountains and hills, and along the course of valleys and ravines; so that watchful and intelligent observers may derive from the visible memorials of the past, the valuable suggestions for their own guidance. I remember well a painful illustration of what has just been said, which took place before my own eyes in the Crimea. At Balaklava, the Sardinian army took up a position in a valley where some of our own works of a temporary character were also constructed. On one of the Sundays in the month of May, 1855, a sudden flood swept through this valley, carrying with its waters the ruins of the works that impeded its progress, and causing both a sacrifice of life, and the destruction of property of very considerable value. Now, the possible occurrence of such an event ought to have been foreseen by the aspect of the locality itself, and the occupation of that valley ought to have been prevented. The bare mountain sides, and vast masses of disintegrated soil and rock so palpably had been washed down during storms of rain from higher ground, that they told significantly, not only of floods that had taken place there, but of the unquestionable probability of future repetitions of similar destructive incidents.*

When I come to treat of the construction of waterworks, I shall

* Inundations have taken place during the past autumn (that of 1868) of the most terribly destructive character, in Switzerland, and especially in the cantons of St. Gall, Grisons, Tessin, Valais, and Uri. Upwards of seventy human lives are known to have been lost; 25,000 acres of cultivated land have been covered beneath heaps of *débris*; more than 100 bridges have been swept away, and a still larger number of houses destroyed, or seriously injured; many miles of road also have been broken up, and the railway of the Rhine Valley has not been in working order for more than thirty days. This wild outburst of the elements, while it declares that the powers of nature are not less terrible now than in past ages, warns engineers not to rest content with calculations based on ordinary averages. It must be added, that at the time of these fearful inundations in Switzerland, the waters of Lago Maggiore rose 18 feet above their customary level. As another instance, bridges recently erected in the colony of Natal, at a cost of some £40,000, have been swept down this autumn (1868), because the engineers had failed to provide for such a flood.

have to revert to what has been said on the subject of excesses above averages, and it will be my duty to impress upon your minds the absolute necessity of forming a correct estimate both of the area that is to be brought under control, and of the maximum volume of water with which you have to deal. It is well for the engineer to make himself master of all details connected with rainfall; but, at the same time, he must remember that he has not to apply his knowledge of such matters upon a uniform principle on every occasion—he is not to make a rule-of-three proposition of area, rainfall, and flow of water from the ground, and then act systematically upon the result, be the circumstances and requirements what they may. The engineering treatment of water differs essentially, when the object in view has reference to sewers and drains, from what may be necessary in connection with waterworks. In countries where there may be a rainfall of 16 inches in twenty-four hours, it would be mere folly to contemplate the construction of sewers which would be capable of carrying away, beneath the surface of the ground, such vast volumes of water. In cases of this kind, engineers have to provide means for safely conveying away, over the surface of the ground flood-waters. Sewerage and drainage, while in some degree affected by rainfall, are of a different character from waterworks. Main sewers must be projected and constructed on principles that have a direct bearing upon their own offices. It will be understood, therefore, that I am now strongly pressing the necessity of studying and acquiring a sound knowledge of the excesses that are committed by nature, in order more especially to introduce the consideration of one of the two great practical questions connected with waterworks, both for impounding rainfall-waters so as to provide for water-supply, and also for controlling flood-waters and preventing their destructive operation.

The conclusions to be drawn from the foregoing remarks may be summed up as follows:—

1. Civil and military engineers ought to study meteorology, as liable to affect sanitary engineering works.
2. Main-sewers, drains, and waterworks are affected by rain, both in drought and when in excess.
3. Evaporation from the salt ocean produces fresh-water, which forms springs, streams, rivers, and lakes.
4. The volume of rain which falls in any one year may be described as due to the evaporation and condensation of that year.
5. The fall of rain is influenced by cosmical and terrestrial causes, and man interferes with such causes only in a fractional degree.
6. An engineer, before commencing works, should study the geology, aspect, contour, and other peculiarities of a country; and learn, as far as may be practicable, the extent of meteorological excesses to be expected in that section to be dealt with.

7. Rainfall varies from an average of 300 inches annually at the tropics, to twenty inches annually, as on the east coast of England. Averages must not, however, be relied upon. A tabulated list of excesses, both of drought and of flood, will be of most value to engineers, civil and military.
8. Although the annual fall of rain is so wide apart as 300 inches at the tropics, and twenty inches in England, a thunderstorm in England may, for a short period, be as violent as in the tropics, and comparatively as destructive.
9. Seasons are not modified in their meteorological character by any works of man. The rays from the sun acting on the ocean; and aerial currents, which generate and move vapour and cloud, can only be affected and modified by cosmical changes.

NOTE.—Growing timber evaporates water to the extent of 200 times the weight of woody fibre deposited, and this in every form of vegetation, from grass to forest trees. A forest prevents surface evaporation in two ways: by excluding the sun's rays, and by impeding the flow of air over the surface; denuding a country of extensive forests will, therefore, necessarily affect the subsoil, the springs, the streams, and rivers, and the atmosphere over the area denuded, but will not affect the great operations of nature in her excesses, either of drought or of wet, as these excesses do not depend on local influences.

ON THE SEWERING OF TOWNS AND DRAINAGE OF HOUSES.

(JOURNAL OF THE SOCIETY OF ARTS, *March* 21*st*, 1862.)

TOWN sewerage is certainly co-existent with the Roman Empire, and earthenware pipes are, probably, as old as the art of pottery. It has been ascertained that pipes of earthenware, hand thrown, on a potter's wheel, and not unlike, in form and dimensions, to hand-made pipes of the present day, were used throughout the East in the remotest periods we are acquainted with, to conduct springs of water for human uses.

Earthenware pipes have been found beneath the great mounds of Assyrian ruins, which pipes are supposed to have been drains; and the stalls in the Colosseum of Rome were drained with earthenware pipes. Earthenware pipes were also used by the Romans for watercourses.

The cloacæ of Rome, including the Cloaca Maxima, according to Livy, are as old as the reign of Tarquinius Superbus. Some authors declare that the construction of these public sewers must belong to an Etruscan nation, which preceded the birth of Romulus.

These old sewers, the ruins of which are to be seen in Rome to this day, were also sub-ways and sewers, having raised paths along the sides with side-entrances for tributaries, from palaces and fountains. There were large cloacæ in the several cities throughout the empire, as mentioned in Pliny's letters to Trajan. I have met in the works of travellers, with descriptions of other ancient sewers and drains found beneath ruins in the East, the date of the formation of such sewers being lost in the darkness of antiquity. It is, no doubt, impossible to trace out the origin of sewers and drains; their invention, construction, and use, probably took place and commenced with civilization. We cannot, however, settle this point this evening. We have another purpose, namely, to discuss the uses and the abuses of sewers and drains at this day.

The Roman cloacæ were, probably, in many instances, of the character of the great sewers in this metropolis—the Fleet, the

Ranelagh, and others,—watercourses enclosed and arched to serve as sewers. The remains of sewers and drains found amidst ruins show us that their application was limited, and their uses only imperfectly understood. If sewers and drains had been generally in use amidst the populous cities and towns of antiquity we should now find their remains abundantly, as we know the extent of the Roman Empire more fully and better by the buried remains of Roman pottery than by written history, or than by any ruins, or traces of ruins remaining on the surface. Brick-sewers and earthenware pipe-drains, if they had ever existed, would have been as enduring in their materials as frail pottery, or as the stone and brick cloacæ of ancient Rome and the drains of the Colosseum. We do not find such remains in abundance, and therefore conclude that a limited construction only took place for special purposes. The Roman cloacæ were originally under the superintendence of the censors; subsequently under that of the ædiles. The Emperors Agrippa and Trajan constructed many cloacæ during their reigns. We, in these modern times, divest our Imperial Government of all such useful power.

Earthenware pipes, of three and four inches diameter, were made in England more than a half-century since, in Lambeth and in other places. Mr. Doulton, sen., can recollect their being made during this space of time, and I have received other evidence as to the make of earthenware pipes 40 or 50 years ago in England. The first modern use of them, for sewer purposes, was suggested by Mr. Edwin Chadwick, C.B., soon after the year 1840. Mr. John Roe states in his Report to the Harrow Local Board of Health (1854):—"The introduction of stoneware pipes for general drainage arose from a suggestion made by Mr. Chadwick to me, in his desire to obtain smooth interior surface; and the first sewer-pipes made for that purpose in the metropolis were for the Holborn and Finsbury office." In consequence, Mr. Roe further states, "immense benefit to sanitary measures has been afforded by the use of earthenware pipes, where judiciously applied and properly laid. They save fully two-thirds the cost of brick sewers; that is, where brick sewers for a town would cost £30,000, the same town may be sewered for a cost of £10,000, and the cheaper pipes will effect the work and be far safer to health and life than the costly brick constructions." Combined back-drainage is of the utmost importance, in point of economy, and also in efficiency of working, where the drain-pipes are properly laid. There are many thousands of instances of successfully combined back-drainage, in scores of towns, and complaints of failure or of annoyance are very rare. I do not think they amount to one per cent. of the work executed. Mr. John Roe, in 1854, stated that, "36 years previously (1818), 200 houses on one estate, in the Holborn and Finsbury districts, had combined back-drainage, and no complaint of their working, or otherwise, ever came in that period of time to the office." Mr. Roe further states, "in many country towns and places back-drainage may be usefully adopted." This is the doctrine of the first Board of

Health anticipated and confirmed. In some places back-drainage will be impracticable, and, of course, should not then be adopted.

It is a great advantage to have a regular flow of water through any sewer. Drains are choked more from want of water than by having too much passed through them. Combine drains as much as practicable; lay them well, joint them evenly, properly, and smoothly, and there will be very few, if any, chokings.

Fully to understand the worst effects of want of sanitary arrangements in towns, we must go back to the days of the plague, sweating-sickness, and other similar diseases, and read up the literature of 1600 and 1700, by Nathan Hodges, M.D., on the Plague of London, 1665; a Discourse on the Plague, by Dr. Mead; an Essay on the Different Causes of Pestilent Diseases, by John Quincy, M.D., and others; until we come to James Lind, M.D., and Sir John Pringle: the one on diseases in the navy, and the other on diseases in the army. We may then visit the cities and towns in the East, where plague rages to this day, and see the causes in existence which prevailed in England two centuries since, and some of which causes prevail even now. Filth, squalour, darkness, neglect, vice, crime, and premature death; an annual mortality of 40, 50, and 60 in the 1,000 regularly, with an increase up to 100, 200, and even, in some places 500, or a moiety of the entire population in one year, of plague and general sickness—"the living too few to bury the dead." The annual mortality of England at present in towns ranges from 30 to as low as 15, and even 11, in each 1,000. It is thought 15 ought not to be exceeded even in our towns.

The Sanitary Commission of 1855, in the Crimea, showed what could be done for an army in the field, where the mortality fell below that of the same troops in barracks at home; the French army knowing no such abatement. When fever had been all but banished from the British army and hospitals, the French at the end of the war were said to be losing by sickness in hospitals at a rate of 5,000 per month. 15,000 men perished in hospital during the last three months of the war, as per French army medical returns.

There are, no doubt, many causes for disease in excess; but overcrowding, defective ventilation, and surrounding filth, seem to be the worst. Proper sewers and drains will improve a town, but will not do all that is required.

The causes of fever in Liverpool, previous to the year 1840, were overcrowded cellar dwellings. The causes in Glasgow and in Edinburgh are overcrowded upper rooms and attics. The narrow streets, crowded houses, and small rooms of many continental towns may be improved by sewerage, drainage, surface pavements, and regular cleansing. But many of the causes of disease in excess might remain,

"Sewer," according to Lord Coke, a place where water "issues," or, vulgarly, "sues," whence the word "suera," or sewers. There are laws relating to sewers from the time of Magna Charta to

recent times. Callis, on the law of sewers, is the great authority*. These laws, however, relate to sea defences, weirs, rivers, estuaries, and land-floods, rather than to town sewers.

Many persons use the words sewer and sewage improperly. They should be used as—

Sewer, a public sewer in street or road.

Sewage, that which flows through a sewer—the fluid.

Sewers or sewerage, the plural of sewer.

* *Laws regulating Sewers.*

The laws regulating sewers are as old as any laws of which any traditional or written records exist. Such laws are named in Domesday Book. There, however, appears to have been a consolidation of the laws of Sewers, 23rd H. 8th, cap. 5. Full information may be found in a work on sewers by Robert Callis, Esq., Sergeant-at-law, in certain lectures delivered at Gray's Inn, August, 1622, and published 1647.

These laws on sewers, as defined by Callis, were for purposes as undernamed:

"First.—To prevent flooding of marsh grounds lying in maritime countries.

Secondly.—To provide that rivers and streams may have their passages made clear, and their walls, banks, and other defences repaired, kept, and maintained.

Thirdly.—To improve and maintain ports, havens, rivers, and navigable streams.

Fourthly.—To provide redress and remedy in cases of dispute, &c.

And Fifthly.—To provide for the construction and protection of bridges, calceys, passages, and ways.

The law of sewers doth distribute itself into these particular branches:

First—Into matters of defence this statute maintaineth are these following, viz.
1. Walls.
2. Banks.
3. Ditches.
4. Gutters.
5. Sewers.
6. Gouts.
7. Calceys.
8. Bridges.

Secondly—Into matters of offence which this statute termeth less impediments and annoyances, which are to be put down or reformed, as cause shall require.
1. Streams.
2. Mills.
3. Ponds.
4. Fish garths.
5. Milldams.
6. Locks.
7. Hebbing-weirs.
8. Hesks.
9. Floodgates.
10. Other like impediments."

These extracts show that some of the oldest laws have been provided to maintain and regulate the outfall of rivers. These laws may have fallen into disuse, or have been superseded by private or local Acts of Parliament, obtained from time to time. But much good has, no doubt, been accomplished by the general law, especially in the Fen Districts and several marshes where Commissioners of Sewers hold jurisdiction.

At present some available law is required for the conservancy of rivers, not only at their outfall, but from their sources along their entire course, to prevent or to abate as much as may be the abuses and nuisances detailed.

Rivers are liable to abuse from many sources at present, and there is neither general nor local power to prevent such abuse.

Drain, a tributary to a sewer from house, building, or court.

Drains or drainage, the plural of drain.

Sewers were first constructed in London in 1428 under an Act (6 Henry VI., c. 5) amended by Parliament in the reign of Henry VIII., and since this period to the present time there have been many amendments and alterations of laws for regulating sewers, into which I do not propose to inquire. The streets of London were begun to be paved in 1533. The first sewers in London would, no doubt, be in the several valleys on the line of existing watercourses, the Fleet Ditch, the Ranelagh Level, &c. These watercourses were arched over, and the drainage of the adjoining streets and houses passed into them.

Stowe states that, "Anciently, until the time of the Conqueror, and two hundred years later, this City of London was watered (besides the famous river of Thames on the south part), with the river of the Wells, as it was then called, on the west; with a water called Walbrook running through the midst of the City into the river of Thames, sewering the heart thereof; and with a fourth water, or bourn, which ran within the city through Langbourn Ward, watering that part in the east. In the west suburbs was also another great water, called Oldborn, which had its fall into the river of Wells."

The Fleet Ditch* was no doubt originally (in ordinary weather) a stream of bright, sparkling, sweet, and wholesome spring water —a river of "wells." But as early as 1290 the monks of White Friars complained to the king that the putrid exhalations arising from it occasioned the deaths of many of the brethren. The Fleet continuing to receive additional impurities, until it became in the time of Pope—

> "The king of dykes, than whom no sluice of mud
> With deeper sable blots the silver flood."

Barges are said to have sailed up the Cloaca Maxima and the Fleet sewer alike; in both instances natural watercourses having been arched over and made receptacles of sewage.

Although the first formation of public sewers in the British metropolis dates so far back as 1428, by far the greater portion of 1,500 miles of the main sewers in London have been constructed since the year 1824, Mr. John Roe having had the perseverance, honour, and credit of effecting more improvements in the main sewers of his districts, Holborn and Finsbury, up to the end of his period of service, than any other man. The improvement of adopting the egg-shape in place of vertical sides for sewers, the introduction of side-entrances, and means of flushing, and the experiments carried out by Mr. Roe, and tables based on these experiments, are invaluable for the metropolis. Mr. Roe found the construction of sewers a matter of guess; he left it a matter of scientific certainty. If all the sewers of this great metropolis had

* "Fleet." This name is derived from the rapid flow of water from the higher districts drained.

been laid out and constructed on the plan proposed and adopted by Mr. Roe, in his divisions, vast additional sums of money would have been saved, and (humanly speaking) many lives prolonged; the flat-bottomed sewers which now exist in Belgravia would have had semi-circular channels, and the deposit which now accumulates and corrupts would have been regularly washed out, or periodically "flushed" out at short intervals. Mr. Haywood has more recently done for the City what Mr. Roe did for Holborn and Finsbury.

The ventilation of sewers by vertical shafts and open grates in the centres of the streets was, no doubt, an improvement, though a very clumsy and disagreeable plan. Previous to the formation of these open ventilators, typhus and typhoid fevers prevailed in many houses connected by drains with the sewers and near the untrapped gully-holes. Mr. Fuller, a medical gentleman, in his evidence, 1834, states that eight-tenths of all the cases of typhus fever he witnessed he could trace to foul drains or foul gullies. The late Dr. Southwood Smith gave evidence to the same effect.

At present there is much injury effected by sewer gases passing through drains and into houses. In 1859, on the use of a disinfectant having a powerful odour, all the houses directly drained by the sewers were tainted, shewing that there was a flow of air from the sewers to the houses. This should not be, and can only be avoided by external ventilation of each house-drain.

The progress of a nation may be measured by increase of population, by spread of education, by increase of commerce and wealth, by increased value of human life and respect for it, and by improvement in morals, in obedience to the laws of the realm, and in religion. We may read, in the eloquent pages of our great historian, Macaulay, how England appeared about the year 1688. He wrote:—"Everything has been changed but the great features of nature and a few massive and durable works of human art. We might find out Snowdon and Windermere, the Cheddar Cliffs and Beachy Head—we might find out here and there a Norman minster, or a castle which witnessed the wars of the Roses; but, with such rare exceptions, everything would be strange to us. Many thousands of square miles which are now rich corn land and meadow, intersected by green hedgerows, and dotted with villages and pleasant country seats, would appear as moors overgrown with furze, or fens abandoned to wild ducks; we should see straggling huts built of wood and covered with thatch, where we now see manufacturing towns and seaports renowned to the furthest ends of the world."

The population of England, in 1690, was computed at nearly five millions and a half. The manners of the inhabitants were in accordance with the state of the country. In the northern counties bands of Scottish marauders fought with moss-troopers—the parishes were required to keep bloodhounds for the purpose of hunting free-booters—oxen were penned at night beneath the overhanging battlements of the residences—the inmates slept with arms by their sides—and, on a journey, it was necessary to carry provisions, for

the country was a wilderness which afforded no supplies. Such was the state of England at the commencement of the year 1700, or little more than a century and a half since. To find a parallel to this state of things, we must now go to Russia in the north, and to the cities of the Sultan in the east. Here we may see vast tracts of land uncultivated—the inhabitants wearing, and even working, with weapons of defence and offence in their belts or sashes—cities and towns reeking in filth—hovels for houses—food of the worst and poorest character—no security for person or property, human life having the least possible value—poor cultivation of land—no proper roads—in the towns no sewers no drains, but a maximum of human misery and degrading vice in the East, and of drunkenness and ignorance in the North.

To ascertain the state of England in our own day, and at the present time, we must study in "Blue Books" the sanitary reports; and although a commencement of sanitary work has been made, there are vast and wealthy populations living amidst cesspits and cesspools. The good work has, however, been commenced—about 400 cities, towns, and places in England having adopted the powers of the "Public Health Act," 1848; or of the "Local Government Act," 1858. The "Common Lodging-Houses Act" of Lord Shaftesbury may be adopted; and, where put in force, the results are most beneficial.

The question of sewerage and drainage concerns the poor more than the wealthy. Firstly, on account of numbers; and secondly, because of close crowding. The poor must live, or linger rather, in squalor, sickness, and misery, and die prematurely, in such habitations as are provided for them. The fatal room tenements in English towns, the mud cabins of Ireland, and the boothies of Scotland, all tend to fill our gaols, lunatic asylums, and workhouses. When shall we learn and fully comprehend the fact, that it will be more in accordance with the requirements of civilisation, and even more economical, to prevent vice, and to make virtue possible, rather than to expend all our energies on reformatories; to make home comfortable rather than to build and endow public libraries, lecture-rooms, and reading rooms? Do not neglect these, but first make the poor man's home wholesome.

The preponderance of low rentals is shown in the case of Manchester and Salford. From a return by the Poor Law Board of the numbers and occupiers of dwellings in parliamentary boroughs, it is shown that in Manchester, in 1859, there were 64,426 separate dwellings, of which number 24,457, or 38 per cent., were of £10 annual rental or upwards; 22,538, or 35 per cent., below £10 and above £6 rental; and 17,431, or 27 per cent., not exceeding £6; or, in the whole, about 62 per cent. at and below £10 rental.

In Salford there were 20,156 dwellings; 5,205, or 26 per cent., of £10 rental and above; 8,131, or 40 per cent., of £6, and below £10 rental; 6,820, or 34 per cent., not exceeding £6 rental. Taking Manchester and Salford in one district, there were 84,582 dwellings, of which 29,662, or 35 per cent., were £10 rental

and upwards; 30,669, or 36 per cent., of £6, and not exceeding £10 rental; and 24,251, or 29 per cent., at and under £6 annual rental.

Many of the houses below £8 per annum rental are of faulty construction. They are generally in rows, back to back, having no back doors nor windows, no yard nor privy, no sinkstone, nor internal water supply; many sleeping rooms have no flue, nor adequate means of ventilation; privies have to be used in common, and, of course, are not what the name implies; they are frequently ruinous, and sickeningly dirty. Experience has shown that numbers of families should not be compelled to use privies common to several houses, unless regular cleansing is enforced. Every dwelling-house should have its own convenience. It is a libel on the poor to say they will not care for their own comfort. There are thousands of instances to the contrary. In Manchester, for the poor, water-closets are the exception, because the local municipal regulations discountenance them. The excuse offered by the Corporation is, "Supplying the poor with waterclosets, would waste water, and foul the rivers." Proper apparatus will prevent the first, and intercepting sewers the latter.

The annual death-rate in Manchester is 30·56 per thousand, or double the death-rate in some districts. The death-rate throughout the manufacturing towns of Lancashire and Yorkshire generally is high, and will continue to be so until better sanitary regulations are adopted and enforced.

London shows a diminished death-rate in proportion to the abolition of cesspools, although the sewerage is most defective, and the River Thames is fouled. Many thousands of cesspools have been abolished in the metropolis, probably not less than 100,000, within the last twenty years, but many thousands remain. Mr. John Roe, and some of the other district engineers, improved miles in length of the metropolitan sewers and drains, but there are still many miles in length ruinous and foul. London is, however, much more healthy than the manufacturing towns of Lancashire and Yorkshire.

Those who wish to experience the horrible character of the cess-pits and middensteads of Manchester, Liverpool, and other northern towns, should study the statistics as they are weekly recorded, of 1,200 and 1,400 such places emptied, and then make a few night inspections of the localities in the hands of the "night-men;" the stench is abominable, many times worse than the Thames at its worst. The rivers flowing through Manchester can scarcely be worse than at present. The Irwell, the Medlock, and the Irk, are a disgrace to our civilization. They are fouled from their sources to their estuary; and if the erection of water-closets could be absolutely prohibited, the construction of intercepting sewers should be made imperative. The solids of sewage can be precipitated, but agricultural land is the proper place and use for sewage.

In many cities and towns where sewerage and drainage are carried out, water-closets are in general use. This is the case in

the metropolis. For several years past some 1,000 soil-pans have been made and sold per week, or some 50,000 per annum, and they are, of course, used. In the cities and towns of Berwick-upon-Tweed, Alnwick, Morpeth, Carlisle, Lancaster, Halifax, Worthing, and many other places in England, the poor use this convenience, and do not abuse it. In Manchester 100,000 loads of night-soil are annually removed at a loss of some £6,000 per annum. In London the removal of dry ashes produces an income to the parishes.

There is no general rule for the dimensions of town sewers for populations below 100,000 in proportion to surface area; and any engineer who adopts the dimensions given in certain published tables will most probably make an expensive mistake for the district in which he is operating. The tables which are based on experiments made in the Metropolitan sewers are no doubt correct and absolute for the districts from which they were constructed, and will be applicable to any other similar district, if all the peculiarities and contingencies are similar, but they are not applicable to towns generally. I have never used these rules, and should have caused great waste of money if I had done so. The science of engineering cannot be tabulated, and this truth ought to be inculcated on every student. As well say that all sorts of diseases can be cured with one set or sort of pills, as that tables of dimensions of sewers can be relied upon, without the experience of practice. The published tables I allude to have worked injury, not only in Great Britain, but all over the continent, where many sewerage works have been attempted. The civilized world looks to this country for practical information on this subject.

The recorded experiments of the best hydraulic engineers on the flow of water in open channels and in pipes may be relied upon. There is little to learn in this branch of hydraulics. Pipes have capacity in proportion to the square of their diameters, and water obtains downward velocity in strict accordance with the laws of gravity, modified by friction in its thousands of forms. The invert gradient of a sewer is one element in the law of flow. The head of water and delivery are other elements, giving velocity and scouring power. I only object to tables of sectional dimensions for general use. The town of Alnwick, in Northumberland, with its 2,000 acres of drainage area, its 7,000 population, and some 1,000 water-closets, is sewered by an earthenware pipe 18 inches diameter, and having a gradient of 1 in 400. Carlisle, with its 1,900 acres of drainage area, and 35,000 population, has an outlet sewer of 3 ft. 9 in., by 2 ft. 6 in., with a fall of 1 in 700.

At Worksop the outlet-sewer is an earthenware pipe, 15 inches diameter, laid at an inclination of 1 in 600. The population is upwards of 7,000, and the drainage area very large.

At Lancaster the outlet sewer is of brick, 5 ft. 3 in., by 3 ft. 6 in., and laid at an inclination of 1 in 1,000. The population is about 15,000, and the drainage area considerable, having a rapid fall in some parts.

At West Ham, with an area of 4,730 acres, principally of flat

water-logged marsh land, the outlet sewer is of brick, 5 ft. 3 in. by 3 ft. 6 in., having a cast-iron invert laid level for a mile in length, and at low-water line of spring tides.

In all these cases the dimensions of the outlet-sewers do not accord with the tables alluded to, and yet the sewers perform the work required to be done. Surface-water and heavy falls of rain pass, as previously, over the surface, but there is not a duplicate system, nor do I advocate such.

At Carlisle the outlet is frequently blocked by land-floods; at Lancaster, daily, by tides; and at West Ham pumping is resorted to.

The first questions an engineer should ask himself with respect to any district or area to be sewered should be these:—"How have surface-waters passed off up to this time without the aid of sewers or drains?" "Have any surface impediments been formed; if so, what are the effects, and can such impediments be removed?" "Have houses been erected and cellars excavated in improper places, and where injurious flooding cannot be prevented excepting at a ruinous cost to the rated property of the district generally?" "Can watercourses in the valley lines be deepened at a moderate cost?" and, "Can embanking and pumping be resorted to economically?" "Are there any mills and milldams which impede drainage and cause continuous injurious subsoil—flooding and injurious flooding at intervals?" All these questions have a most important bearing on the dimensions of sewers.

It may look very egotistical, but I can better give an account of my own practice than that of any other person, and detail my own experience more confidently than stereotype it in tables, which must, in such form, be misleading and injurious.

Natural streams down valley-lines should never be converted into sewers. The maximum flow of water in such streams is to the minimum as three hundred or four hundred to one. Any sewer formed in such valley-line of sufficient capacity to carry off flood waters, would be much larger than requisite for the ordinary flow, and would become a cause of nuisance in dry weather. All valley-lines should be improved, and the beds of natural streams should be preserved free and open for the escape of surface and flood waters. Sewers and drains should be of sufficient capacity to remove roof, yard, street sub-soil, and slop-water from the area drained during ordinary weather, and should be graduated to the amount of work to be done. Flood-water-outlets or overflows into valley-lines, or natural streams, to relieve the sewers during heavy rains, should be provided. There may be large gratings to remove surface storm waters at the outlet points of valley-lines, but care must be taken not to make such places large stagnant cesspits.

All sewers and drains should be properly ventilated. This may be effected by connecting down-spouts with house-drains in proper situation; by connecting sewers with tall chimneys; or by providing, on the sewers and drains, ventilating shafts with charcoal filters for

oxidising sewer-gases.* All sewers should have means of inspection, flushing, and cleansing provided. Sewers should be laid in straight lines, and with regular gradients. At each alternate change in direction, or alteration of gradient, a manhole or entrance to the sewer should be constructed. Agricultural drain tiles are laid in straight lines. Ploughing, on the most approved plan, is also in straight lines. In both cases, truth and efficiency of workmanship are attained, and straight sewers and drains insure good workmanship. One defective link breaks the chain; one defective pipe-joint or defective yard of sewer is injurious.

Brick sewers should be formed of radiated bricks, set in hydraulic mortar. Pipes should be jointed with clay-puddle, or with cement, or mortar, or asphalte, according to the nature of the ground in which the pipes are laid. Great care should be taken in laying pipes in rock, in gravel, and also in clay. Many lines of sewer pipes are injured by injudicious filling of a trench, or by a fall of clay or earth crushing the pipes. The inlets of all drains should be properly protected, and the openings should be reduced so that any substance entering the drain may pass freely into the main sewer.

Where a sewer or drain has once choked, and the ground is opened out for repairs, do not close it in again, but construct a manhole or lamphole, that any future obstruction may be removed at once.

Sewers and drains act as subsoil-drains to the full depth at which they are laid. In wet subsoils provision should be made for allowing subsoil-water to enter the sewers. A continuous flow of subsoil water along a sewer or drain is generally an advantage, as the solids of sewage are more readily removed.†

Neither sewers nor drains should be laid under inhabited dwellings. If it be absolutely necessary to carry a drain under a house, the drain should be carefully laid, and the joints made perfectly tight, so as to prevent the escape of sewer gases into the adjoining subsoil. Many lines of earthenware pipe sewers and drains are ruined when laid in porous subsoils with leaking joints. The fluid sewage leaks away, and leaves the solids to accumulate and ultimately to choke the sewer or drain, as the case may be. Puddle should be used in such cases.

All junctions with main sewers should be made at a point above the ordinary water-level in such sewers; and at the junction of a branch with a main sewer the tops of the sewers should be on the same level. Additional fall should be given at junctions or bends, to overcome increased friction. Junction entrances, provided for branch sewers and house drainage, should be protected by earthen-plates, or "disc-plugs." Street gullies should be small, compact, and double-trapped. There should be a sediment box, easily removed and easily replaced, Means of flushing should be pro-

* Charcoal is not now recommended for use as it impedes ventilation, which should be free.

† Where sewage has to be pumped the sewers should be water-tight. Special drains being provided to remove subsoil-water. (1862)

vided in the gully, that choking of the pipe connection with the sewer may be impossible. Large cesspit gullies are a nuisance. Small gullies of cast-iron are generally found the cheapest and best; increase the number of small gullies, rather than construct large cesspit gullies.

Fresh sewage, when properly diluted, filtered, disinfected, and clarified, may be passed into rivers, or into the sea, without causing nuisance or injury to fish. In arranging outlet sewers, provision should be made for applying the sewage to land in the immediate neighbourhood, for agricultural uses, by gravitation, if practicable, if not pumping by steam or other power is available. A town standing on ground having quick gradients requires special arrangements to break the rush of water down and of gases up. This can be done by breaking the line with a vertical fall, placing a flap over the mouth of the sewer, and ventilating at this point. The outlet-ends of all sewers should be protected with a covering flap, to prevent the wind blowing in and driving back sewage gases. A cast-iron pipe of comparatively small dimensions on any river outlet-sewer, will pass the dry weather flow of sewage to and below the summer level of the river, so as not to be a nuisance.

It is not the special province of an engineer to enter into the question of diseases and causes. There are many causes of disease other than filth, the result of no sewerage, or of defective sewerage; and even fevers may break out in a sewered town. Deficient and bad food, defective house accommodation and overcrowding, intemperance, and excesses of any kind, mental excitement, improper and deficient clothing, all tend to disease. The foundation of social improvement and comfort is, however, proper sewerage. The scale may be arranged in the following order, as things necessary in towns for health and comfort to the highest degree :—

1st. Main-sewerage, house-drainage, and street-pavements.

2nd. Good house accommodation; separate rooms for the sexes, with full ventilation.

3rd. Wholesome food, pure water, and proper clothing.

Then may be added, baths, reading-rooms, and museums.

A city of palaces, museums, picture galleries, and of cess-pools, is a sorry affair—a place to avoid rather than to dwell in. The cesspools of Paris detract from the beauties of the city above ground; and who is to visit and dwell in the cities of the continent generally, if they remain neglected? Climate is blamed for producing disease in excess and premature death, but my experience has taught me that in any country or climate we must look to the habits of the people, and within their houses, rather than to the climate, for causes of disease in excess.

The cost of town sewerage works is an important matter; and, as continental governments look to England—and especially to the British metropolis—it is only right that they should have some sort of rule to judge by. In my experience I find that towns of and below 30,000 of population may have complete sewerage at or below one pound sterling per head. Where a population is com-

pacted into a small area, and means of outlet are not distant, as in the cities on the Rhine, the estimate of one pound sterling may be relied on. But large brick sewers, for men to walk and work in, must not be constructed. The sewers must be of small sectional area, and so arranged that they may be cleansed absolutely and perfectly without sending men in and through them.

Rivers and streams are natural outlets for drainage, and since men have dwelt on the banks of rivers, surface refuse has been allowed to pass into and mingle with the waters. There is at present a great outcry against the pollution of rivers by sewers, and the killing of fish. The questions may be asked, "Whether is it better to pollute rivers, or pollute towns and houses? to kill fish, or to kill men?" I do not advocate the pollution of rivers, but the application of sewage to land for agricultural uses. If it will not pay as a commercial speculation, make it compulsory, and pay the cost by rate. By far the most costly condition in any community is filth in cesspools beneath houses, or on the surface around human dwellings.

Proper sewers and drains deliver sewage at the outfall fresh, and in this state fish are not killed, but are fed. The putrid sewage flushed from the foul sewers of the metropolis during hot weather by a thunder storm, taints the river and poisons fish; but even in the hot summer of 1859 the mortality in London was low, although the Thames was foul. As cesspools have been abolished, the public health has improved, and if all the sewers were of sectional dimensions, forms, and gradients (as they may be) to transmit fresh sewage, and not retain it until putrifaction sets in, the public health would be further improved. It is practicable to so improve and manage the public sewers of this metropolis, that sewage one day old shall not remain, but shall be in motion towards some outlet; and in motion there is safety, danger in stagnation.

The full and proper ventilation of sewers and drains is of the utmost importance; drains should be so laid and arranged as to render contamination of the air within houses (by sewage gases) impossible. At present, the sewers of the metropolis, with exceptions in the City, as recorded by Dr. Letheby and Mr. Haywood, ventilate, for the most part, direct to the open air, by means of the vertical shaft from the crown of the sewer. The gases of decomposition rise direct out, and road dirt, stones, and grit fall in. The gases foul the air in the street, and the dirt, ground by traffic through the open grates blocks the invert of the sewers. The proper way to ventilate is to form a side-chamber, or side-shaft, and to place the passage of communication from the vertical shaft by the side-chamber, so that all the gas escaping may be oxidised. The side-chamber receives the dirt falling through the ventilating-grate; it cannot enter the sewers. House-drains may also be ventilated in a similar manner.

Dr. Stenhouse pointed out the true uses of charcoal in 1853. I commenced the use of charcoal for sewer ventilation about the year 1858; and Dr. Letheby and Mr. Haywood commenced their

elaborate and valuable experiments also in 1858. I think I may claim to have been one of the first—if not absolutely the first—to apply the use of charcoal for disinfecting the sewage gases of an entire town, upon a general plan, as part of a sewerage system. I may instance Worksop, Buxton, and West Ham.

Cesspools may be ventilated through charcoal with advantage, where they cannot be abolished entirely, which is the only safe remedy. At the County Hospital, Winchester, a large cesspool, some eight feet diameter, is ventilated through a covering of charcoal. The arch covering of the cesspool was removed; a wire-work basket, about ten feet square, supported on iron framework, covers the entire area of the cesspool, and this is filled with charcoal broken fine (like peas), to a depth of twelve inches. There is a roof over the charcoal to prevent its being wetted by rain, and the whole is walled in so as to leave a clear passage round. It is reported to answer fully; there is certainly no nuisance from cesspool gases at this point.

The following are details of sewerage works executed:—

CARLISLE.

The "drainage area" of the district sewered is about 2,000 statute acres.

The main outlet-sewer for the entire area is 3 ft. 6 in. by 2 ft. 6 in. The sewer is laid with a gradient of 1 in 700. The outlet is extended by a cast-iron pipe to the centre of the river Eden, so as to deliver the sewage into the water of the river in the driest weather. The main-sewer, and the low-lying portions of the city, may be relieved by flood-outlets.

The "drainage areas" of the several "flood-outlets" may be described as under:—

	Areas in Acres.
1. Swift's-lane	330
2. Bitt's-bank	50
3. Castle-mill	170
4. Dow-beck and Milbourn	750
5. Paddon-beck and Newtown	630
Total area in statute acres ..	1,930

The surface was most carefully considered, and all available means were used to prevent damage or inconvenience from local storms and flood-waters. The main-sewers and secondary branches are built of bricks, moulded to the sectional form required for each sewer, and set in engine-ground hydraulic mortar.

Cast-iron pipes were used in crossing under rivers and water-courses and for the main low-water outlet. The means of flushing from surface waters are full and ample. Flushing-valves or sluices are provided on the Caldew, the Eden, Mill-beck, &c., and from a flushing-chamber in English-street (the highest part of the city), the sewers in 28 streets may be flushed.

The sewers are designed to remove all sewage-refuse without pumping. This will be accomplished completely at all ordinary times. An extraordinary flood may block the outlet, and a long-continued rain may then, for a short time, fill the lower sewers, simply because the surface-water flood in the rivers impede all action; at such time the largest sewers would be filled; and, for a time, their delivery would be impeded. There have been as heavy floods in the rivers since the completion of the works as any previously recorded, causing no injury to the sewers. There has been local flooding, but no one blames the sewers as the cause.

The following are details of expenditure:—

Brick Sewers.

Size of Sewer.	Length in yards.	Average cost per yard.						
ft. in. ft. in.		s.	d.	£	s.	d.	£	s. d.
3 9 by 2 6	2,285	29	1½	3,326	19	10		
3 4½ „ 2 3	1,993⅓	24	8	2,455	6	8		
3 0 „ 2 0	1,385⅔	21	6	1,491	16	2		
2 3 „ 1 6	3,209	16	6	2,644	0	11		
Total length of Brick Sewers	8,873 yds.			Cost ..			9,918	3 7

Earthenware Pipe Sewers.

ft. in.	Yards.	Cost. s.	d.	£	s.	d.
1 6	646	9	7	310	2	4
1 3	4,352	8	5½	1,842	6	4
1 0	6,509	6	8	2,167	11	9
0 9	2,509	4	10	608	18	0
0 6	168	3	10	32	4	0
Total Length of Earthenware Pipe Sewers	14,184 yds.			Cost ..			4,961	2 5

Cast-Iron Sewers.

ft. in.	Yards.	Cost. s.	d.	£	s.	d.
2 3	297	61	3½	910	3	2
1 6	677	29	0	981	6	9
1 0	48	18	2	43	10	9
Total Length of Cast-iron Sewers	1,022 yds.			Cost ..			1,935	0 8
							£16,844	6 8

Summary of Sewers.

	Length in Yds.		£	s.	d.
Brick Sewers	8,873	Total Cost	9,918	3	7
Earthenware Pipe Sewers ..	14,184	Total Cost	4,961	2	5
Cast-iron Sewers	1,022	Total Cost	1,935	0	8
Total length ..	24,079		16,814	6	8

Description of Works.	No.	Average Cost.								
	..	£	s.	d.	£	s.	d.	£	s.	d.
Brought forward		..			..			16,814	6	8
Man-Holes.										
On Brick Sewers	67	21	4	7	1,422	7	7			
On Earthenware Sewers ..	60	7	1	1½	423	8	0			
On Cast-iron Sewers	4	9	1	11	36	7	8			
Total Man-holes ..	131	..			1,882	3	3	1,882	3	3
Lamp-Holes.										
On Brick Sewers	18	1	14	6½	31	1	9			
On Earthenware Sewers ..	79	1	17	11½	149	18	6			
On Cast-iron Sewers	2	3	5	3	6	10	6			
Total Lamp-holes..	99	..			187	10	9	187	10	9
Gullies	366	2	19	0	..			1,806	2	0
Flood Outlets	..	..			..			445	16	9½
Flushing Valves and Sluices	..	..			..			341	14	6
Crossing Rivers and Sundry Expenses	..	..			..			747	3	7½
								21,504	17	7
Engineering and Administration.										
Engineer in Chief	..	..			1,150	0	0			
H. McKie, Resident Surveyor, and Inspectors of Brick-work, &c.	..	..			505	9	0			
Incidental Charges, say ..	..	..			150	0	0			
					1,805	9	0	1,805	9	0
								23,310	6	7

Rateable Value.. .. £60,378 7 9 } Annual Rate in the Pound required to repay Principal and Interest in 30 Years, 6d.

Number of Houses, about 6,838.

Details.	£	s.	d.
The cost of draining "self-contained" houses, including one water closet, was about	6	2	1
The same without a water-closet, about	5	6	4
The cost of draining "tenement houses" with one water-closet for each house, taken on an average of 71 tenements, was, per tenement	1	6	7
The cost of draining "tenement houses" without water-closets, taken on an average of 66 tenements, was, per tenement ..	1	10	0

Note.—Where a water-closet has not been substituted, a cesspit has been drained, and the drain is laid at a greater depth, involving larger cost. Where a water-closet has been put up, the cess-pit has been filled up.

All cess-pits should be abolished, as nuisances, which draining only ameliorates, but does not cure.

WORKSOP MAIN SEWERAGE WORKS.—Particulars of Cost.

Description of Works.	Quantities.		Average Cost per yard.	Cost.	Amount.
	Cb. yds.	Cb. yds.	£ s. d.	£ s. d.	£ s. d.
Brick Sewers.					
2 ft. 0 in. diameter, 9 in. thick	64	..	0 19 9½	63 5 3	
2 ft. 3 in. by 1 ft. 6 in. 4¼ in. do.	950	..	0 13 8	648 17 1	
Total Brick Sewers ..	..	1,014	..	..	712 2 4
Earthenware Pipe Sewers—					
15 in. diameter	3,695	..	0 5 3	970 0 4	
12 in. do.	4,084	..	0 4 6½	929 14 0	
9 in. do.	3,537	..	0 3 2	560 2 3	
Total Earthenware Pipe Sewers	..	11,316	..	..	2,469 16 7
Cast-iron Pipe Sewers for crossing canals and rivers, including cost of retaining walls, puddle, pitching, &c.					
15 in. diameter	69	..	2 13 5½	184 7 8	
12 in. do.	18	..	3 5 2	58 13 0	
9 in. do.	12	..	1 13 0	19 16 0	
Total Cast-iron Pipes ..	..	99	..	..	262 16 8
Total Length of Sewers ..	..	12,429 or 7 m. 109 y.			
	No.		Each.		
Manholes	75	..	6 15 6	508 2 9	
Lampholes	48	..	2 1 0½	98 9 9	
Gullies, with drains complete ..	136	..	2 1 11¼	285 3 8	
Three Flushing Chambers and three Overflows	6	..	4 13 8½	28 2 3	
Ventilating shafts	51	..	1 16 6½	93 4 3	
					1,013 2 8
Outlet Works complete.. ..	..	..	.. ..	..	257 1 4
Timber and Concrete in Trenches				57 15 4	
Disc Plugs and fixing				7 17 0	
Making connections with old Sewers, &c.				18 3 11	
Assistance in levelling and sundry expenses				13 12 10	
					97 9 1
Land and Compensation				.. ..	331 19 6
Rent of Pipe-yards and sundry expenses				..	3 16 4
Advertising and Stationery, &c.				..	28 13 9
Law Expenses				..	20 19 9
Engineer-in-Chief				394 3 0	
Resident Engineer—Salary, Office Rent, and Expenses ..				279 18 7	
					674 1 7
Total Cost				..	5,871 19 7

N.B.—Earthenware pipes, 15 inches in diameter, were delivered at Worksop at 11*d.* per lineal foot; 2*s.* 9*d.* per yard.

The prices include all expenses of excavation, timbering the trenches, materials and laying, filling in the trenches, making the ground good, and removing surplus earth.

WORKSOP.—General Description of Works.

The outlet-works for the clarification of the sewage consist of six trenches about 200 feet long, three feet deep, and eighteen inches wide at the bottom, with side-slopes of one to one. These trenches are provided with sluice-arrangements at each end, to allow of the sewage being diverted as may be required, either for cleansing the trenches or for other purposes.

At the termination of the outlet-sewer provision has been made for passing limewater, or other disinfecting fluid, into the sewage, and moveable screens, for intercepting solid matter, have been placed in the trenches. Two outlets for clarified sewage-water are provided into the river Ryton. The area sewered is about 400 statute acres.

The sewer from Bridge Street to opposite Beaver Place is of brick, egg-shaped, 2 ft. 3 in. by 1 ft. 6 in. At the termination of the brick sewer an overflow into the river Ryton is provided, and from this point to the outlet-works the out-fall-sewer is formed of 15-inch earthenware pipes, cast-iron pipes of the same diameter being laid across the river and mill-stream. This outlet sewer has a fall 1 in 600, and serves for the entire district. The sewers are formed principally of stoneware-pipes of 15, 12, and 9 inches diameter. The manholes and lampholes are furnished with moveable covers to admit of the sewers being examined. The ventilating shafts are fitted with charcoal filters, through which the sewer gases are passed and thereby oxidised. Seventy-five manholes, forty-eight lampholes, and fifty-one ventilating shafts are provided on the sewers.

Manholes throughout the entire system are provided with grooves for flushing sluices, and, in addition to these arrangements, flushing-tanks have been constructed at the upper ends of the sewers. Connections, for flushing purposes, have also been made with the open drain or water-course in Chesterfield Road, and with the canal near Eastgate.

One hundred and thirty-six gullies (including five for storm waters) are fixed within the district. The gullies are double-trapped, and are so constructed as to prevent road-dirt and solid substances passing into the sewers. Two overflows for storm-waters have been provided near Beaver Place, and one for Low Town main.

Sewers are laid under the Chesterfield canal at two points, and over and under the river Ryton, and the canal feeder at seven points. In all cases the crossings have been made with cast-iron pipes of 15, 12, or 9 inches diameter.

The site on which Worksop is built presents several natural and artificial difficulties to cheap sewerage works. The valley is flat and liable to rain-floods; the river had to be crossed several times, as also the canal on one side, and the canal feeder on the other. The outlet works are simple on plan and economical in cost.

Expensive tanks have been avoided, and the cheapest, but most effectual, means for intercepting and removing any solid, flocculent, or discolouring matter, has been adopted; and the experience of two summers has shown that these works are efficient.

The proper place for liquid sewage, however, is the land, and the best filter is vegetable soil under full cultivation; but when the sewage is so used at Worksop, the existing outlet-works will be necessary, as it is advisable to intercept any solids and to irrigate with the fluid.

The entire of the sewage of Worksop may be carried on and over land below the outlet-works very cheaply, by contour conduits, and be distributed by surface irrigation. A small outlay on such works, and intelligent management in irrigating and growing appropriate grasses, will prove beneficial to the farmer.

The entire system of sewers in Worksop is fully ventilated by special arrangements for this purpose at 51 places, and these include all upper ends of sewers. The estimated cost of the works was £6,000; the actual cost, including all contingencies, was £5,871.

BUXTON.

Description of Sewerage Works.

Outlets.

Two outlets for sewage have been formed into the river Wye; one near Wye Bridge, and the other opposite Duke's Drive. The outlet-sewers are so arranged, with regard to levels, as to allow of the whole of the sewage being applied, by gravitation, in irrigating land in the valley of the Wye.

Sewers, &c.

The district for sewerage purposes has been divided into two "drainage areas," the main-sewer for each sub-district being formed of 15-inch stoneware-pipes.

In many portions of the town the sewer excavations were made, wholly or partially, in limestone rock. In such cases the trenches were excavated six inches below the proposed level of the sewer, and a properly prepared bed was formed for the pipes by filling in the trench with clay, gravel, or sifted earth. Manholes and lampholes have been provided at all the changes of direction or alteration in gradient of the sewers. Flushing-chambers have been constructed at the upper ends of the sewers, and provision has also been made for flushing from the baths and from the river.

The sewers from "High Buxton" have gradients of about 1 in 10. Overflows into the river Wye, for relieving the sewers during heavy rains, have been formed at river crossings and other suitable points. Ample means have been provided for ventilating the sewers by about thirty shafts furnished with charcoal filters.

My estimate for the public sewerage-works of the district was £3,203. The actual cost of the works as carried out was £3,107. 6*s.* 10*d.*

SEWERAGE WORKS.—PARTICULARS OF COST.

EARTHENWARE PIPES.	Quantity.	Average Cost.	Amount.
	Lineal yards.	£ s. d.	£ s. d.
15 inches diameter	1,590	0 8 3	657 11 9
12 inches do.	2,522	0 6 0	756 19 2
9 inches do.	2,151	0 4 6	483 10 8
Total Length of Sewers ..	6,263		
	Number.		
Manholes	45	11 11 0	520 17 4
Lampholes	35	5 11 0	196 1 9
Gullies	20	3 2 0	62 0 0
Cast-iron Pipes for crossing river, outlet-works and sundry works in connection with sewers—compensation, &c.	..	..	46 1 2
Engineering and Superintendence..	..	..	384 5 0
			3,107 6 10

WIGAN.

Mr. John Law Hunter, borough surveyor, has given me the following information as to drainage in Wigan:—

The cost of draining cottages of about £3 or £4 rental, has been at an average of . . .	£1 1 0
Ditto ditto £7 or £8 rental. . .	1 11 0
Ditto ditto £14 or £15 rental . .	1 13 6

4,228 houses have been drained at a total cost of £8,796. 19*s.* 10*d.*, or an average cost, per house, of £2. 1*s.* 4*d.*

In draining 4,228 houses, 36,960 lineal yards of earthenware-pipes have been used, being an average of 8¾ yards per house. The earthenware-pipes used are from 9 inches to 4 inches internal diameter.

Many of the drains have been in use several years, and there have not been any complaints of choking or stoppages.

Water-closets are not in general use in Wigan, but cess-pits, yards, stables, and house-sinks are drained. A general use of earthenware-pipe drains prevents rats living in the sewers and drains; as they have neither food nor means of shelter.

DISTRICT OF WEST HAM, ESSEX.

Public Sewerage Works.

The parish of West Ham consists of the sub-districts of Stratford, West Ham, and Plaistow, and comprises an area of about 4,735 statute acres.

Population about 35,000, but is rapidly increasing. Annual rateable value, £135,000. The entire area is low and flat. The lowest surface area is near Hallsville, and is about four feet above Ordnance datum.

The highest surface area is near Forest Gate, and is about forty-five feet above Ordnance datum. The difference of level within the parish is, therefore, about forty-one feet.

A considerable portion of the parish is marsh, protected by artificial embankments, from tidal waters and land floods, which banks rise to a height of from six to ten feet above the surface of the land.

This marsh-land is intersected by ditches, and is under the jurisdiction of the Havering and Dagenham Commissioners of Sewers.

The distance from the outlet-works to the end of the sewer near Forest Gate is about three and a half miles; at Bow Bridge two and a half miles; in Romford Road, two miles and three-quarters; in Barking Road, one mile and three-quarters; and in the Lilliput Road, Victoria Docks, one mile and a half.

The outlet-works consist of a pumping establishment and a low water, or relieving flood-water sewer.

The pumping establishment is erected on land purchased by the Local Board at Canning Town, and consists of an engine-house, boiler-house, coal-store, workshop, and engine-chimney, with pumping-wells, outlet-wells, and outlet-pipes.

Two condensing engines (of 40-horse power each), having 34-inch cylinders, and 6-feet stroke, have been provided and fixed. Each engine works two pumps of 48 inches diameter, and 3-feet stroke. The two engines are capable of lifting 30,000,000* gallons in 24 hours. The pumps are so arranged as only to lift to the level of the water in the river; the lowest lift is 8 feet, the highest lift is 22 feet.

The inlet and outlet-pipes, to and from each set of pumps, are 30 inches diameter, having screw-down valves complete. Self-closing flap-valves are fixed on the outlet-pipes at the river wall.

A low-water, or relieving flood-water outlet has been formed at Bow Creek, near Barking Road station. The River Lea at this point is nearly four feet lower, at low water of spring tides, than the bed of the river opposite the pumping-works. This outlet, which is self-acting, discharges the flood-water for several hours each day without pumping. In the outlet-well adjoining the river, two self-closing flap-valves, similar to those at the pumping-outlet,

* 30,000,000 gallons, equal to 300,000,000 lbs., or 133,928 tons.

have been fixed, and, as a precautionary measure, one screw-down sluice has been placed in the manhole in Barking Road.

The larger main-sewers are formed of brickwork; smaller sewers are of stoneware-pipes. Cast-iron pipes have been used for crossing navigable rivers, and also for crossing marsh drains, and for the main outlets. Brick sewers are "egg-shaped" on section, and vary in size from 5 feet 3 inches by 3 feet 6 inches, to 2 feet by 1 foot 4 inches. The whole of the brickwork is set in the best blue lias hydraulic mortar. Stoneware-pipes are circular on section, and have half-socket joints. Cast-iron pipes are circular on section, and are formed with flanch or socket joints. Twenty-four thousand two hundred and twenty-seven (24,227) lineal yards of brick sewers; twenty-seven thousand six hundred and ninety-eight (27,698) yards of stoneware pipe sewers; and two hundred and ten (210) yards of cast-iron pipes, making a total of fifty-two thousand one hundred and thirty-five (52,135) lineal yards, or twenty-nine miles and one thousand and ninety-five yards (29 miles, 1,025 yards) have been constructed and laid within the district.

The sewers, throughout the districts, have been designed with a view of obtaining the best practicable gradients, more especially for tributaries. In some cases, however, it has been necessary to lay the mains with a fall of not more than 1 in 3,520, or 18 inches per mile.

The sewers, on plan, have been laid in straight lines; and, on section, with regular gradients. At each change in direction, or alteration of gradient, a man-hole or lamp-hole has been constructed, affording means for inspecting, and, when necessary, also for cleansing the sewers.

The main outlet-sewers in Canning Town have been laid level, and the inverts are formed of cast-iron, to allow of their being laid and formed under water.

Considerable difficulties were experienced in the construction of the sewers in some portions of the district, arising from loose, wet, spongy, and other unfavourable descriptions of sub-soil, and from other causes. Upwards of three miles of main sewers have been laid with cast-iron inverts, at or near the level of low water of spring tides, at the Barking Road outlet.

About 9,000 junctions for branch-sewers and house-drains have been provided on the main and tributary sewers. A careful account has been kept of these junctions, and has been placed in the hands of the Surveyor to the Board.

The main-sewer crossings, under three branches of the River Lea, consist of cast-iron pipes of two feet six inches, and two feet diameter. At each end of these cast-iron pipes under the rivers a man-hole is constructed with screw-down sluices, which may be put down in case of injury to the pipes under the rivers, and thus prevent flooding in the low districts.

The river-crossings were executed by Mr. Munday in a manner perfectly satisfactory to myself, and highly creditable to the con-

tractor. By staging over the rivers, jointing the pipes, dredging the lines of mains, and lowering each entire length of pipe to its position, stoppage of traffic was rendered unnecessary, and claims for compensation, which might otherwise have arisen, were, by these arrangements, prevented.

Main and branch-sewers have been constructed under the North Woolwich, the Barking and Tilbury, and Eastern Counties Railways, in eight separate places. The railway companies and their engineers afforded every facility for executing these works, and the crossings were completed without accident or stoppage of traffic.

On the sewers, as executed, there are 468 manholes, or means of access from the surface to the sewers for examination, for flushing; and, when requisite, for cleansing; and 197 lampholes for means of inspection, making, on an average of the entire length, one opening to the sewers from the surface of street or road, at about seventy-eight lineal yards each. Manholes have step-irons, flushing grooves, and moveable iron covers complete. Lampholes have moveable iron covers. There are 251 ventilating-shafts provided on the sewers. These shafts are so arranged as to prevent road-drift falling into the sewers and impeding the flow. Sewer-gases are passed through wire baskets containing charcoal, and by this means are rendered innoxious. Seven hundred and eighteen (718) gullies have been fixed within the districts. The gullies are so constructed as to prevent solid or other improper substances passing into the sewers.

Flushing arrangements are of three classes:—First, by the admission of water into the sewers through sluices, hose-pipes, or valves; second, by screwing down fixed sluices built in certain manholes, allowing the sewage-water to accumulate, and suddenly raising the sluice; and, third, by inserting loose paddles in the grooves provided in nearly all the manholes. Thirteen flushing-valves and forty-two flushing-sluices are fixed in the sewers. By one or other of these arrangements, the whole of the sewers within the district may be flushed. About 310 feet in length of river-wall has been put in, bounding the land belonging to the Local Board. This wall is constructed of brick and concrete, coped with stone, and is sound, firm, and calculated to be enduring. A wharf has been formed, at which coals for the engines are landed, but there is space for other traffic.

WEST HAM.

Particulars of Cost of Main Sewerage.

			Amount.	Total.
Brick Sewers.				
Ft. In. Ft. In.	Yds.	Yds.	£ s. d.	£ s. d.
5 3 by 3 6	1,117	..	3,901 6 10	
4 6 „ 3 0	2,562	..	7,476 4 0	
3 9 „ 2 6	1,463	..	4,085 9 3	
3 0 „ 2 0	7,588	..	12,376 7 11	
2 6 „ 1 8	3,182	..	5,566 7 7	
2 3 „ 1 6	8,231	..	9,156 17 11	
2 0 „ 1 4	84	..	59 15 6	
Total Brick Sewers ..	..	24,227	..	42,622 9 0
Earthenware Pipe Sewers.				
15 inches diameter	10,646	..	6,671 14 11	
12 inches do.	16,564	..	7,061 2 10	
9 inches do.	488	..	142 12 7	
Total Earthenware Pipe Sewers ..	..	27,698	..	13,875 10 4
Cast-iron pipes for river crossings, &c.	..	210		
Total Length of Sewers or 29 m. 1,095 yds.	..	52,135		
	Number	Number		
Manholes and Ventilating Shafts	232	..	3,455 5 4	
Manholes	236	..	3,160 4 3	
Lampholes and Ventilating Shafts	15	..	97 8 3	
Lampholes	182	..	1,008 9 8	
		665		7,721 7 6
Gullies and pipes fixed complete	..	718	..	3,185 14 5
Outlet works, pipes, valves, &c.			..	1,754 14 5
River-wall, wharf, and roads, at engine-house, and reparing roads			..	2,677 9 2
Engine-house, boiler-house, chimney, and other works in connection therewith			..	5,098 6 10
River crossings			..	1,644 6 7
Engines, boilers, and pumps			..	3,978 9 10
Cost of Works.				82,558 8 1
Engineering and superintendence			6,161 9 8	
Land and compensation, and law charges ..			2,999 8 8	
Coals and Tallow, &c., for engines			303 5 3	
				9,464 3 7
Total Cost			..	£92,022 11 8

N.B.—This amount includes purchase of implements, tools, and materials in the hands of the Local Board.

ALNWICK.

DETAILS OF HOUSE-FITTINGS.

First-Class House.—Rental £40 per Annum.

Water Supply.	Net Price.	Price Fixed.	Total Cost Fixed.
	s. *d.*	*s.* *d.*	£ *s.* *d.*
143 lineal feet of 1 inch galvanised tube	0 7½	0 10½	6 5 1
56 „ ¾ „	0 5¼	0 8¼	2 4 8
34 „ ½ „	0 4½	0 7½	1 1 3
16 in. of lead pipe for water-closet pan	0 10	..	0 0 10
3 in. of india rubber tubing for ditto	1 1	..	0 1 1
1 ¾-in. self-closing ferrule cock for ditto ..	7 4	..	0 7 4
1 1-in. elbow ferrule with union joint	3 10	..	0 3 10
1 1-in. elbow piece	1 6½	..	0 1 6½
2 ¾-in. „	1 0	..	0 2 0
5 ½-in. „	0 7½	..	0 3 1½
1 1-in. socket piece	1 1	..	0 1 1
2 ¾-in. „	0 8	..	0 1 4
2 ½-in. „	0 6	..	0 1 0
1 1 to ¾-in. taper piece	1 1	..	0 1 1
1 1-in. T-piece	1 7	..	0 1 7
2 1 to ½-in. T-pieces	1 7	..	0 3 2
1 1-in. stop-cock	7 11	0 6	0 8 5
1 stop-cock case	4 6	1 6	0 6 0
1 1-in. screw plug, 9*d.*; 1 ½-in. ditto, 4½*d.* ..	1 1½	..	0 1 1½
1 ½-in. bib tap	2 10	0 6	0 3 4
			11 18 11½
Sewerage.			
211 lineal feet of 6-in. earthenware pipe	0 5½		
68 „ 4-in. „	0 4		
6 „ 6 to 4-in. junction pipe	1 6		
3 „ 6 to 6-in. „	1 6	Price varies according to depth.	12 0 9
1 „ 6 to 4-in. taper pipe	1 4		
2 „ 6 in. bend pipe	1 6		
1 water-closet pan and fan, old seat refixed ..	8 6	17 0	0 17 0
3 earthenware yard sinks	6 0	9 6	1 8 6
2 6-in. bell traps	2 6	8 6	0 17 0
Sewerage	..	..	15 3 3
Water	..	..	11 18 11½
Total	..	..	27 2 2½

Second-Class House.—Rental £15 per Annum.

Water Supply.	Net Price.	Price for Fixing.	Total Cost Fixed.
	s. *d.*	*s.* *d.*	£ *s.* *d.*
6 lineal feet of ½-in. galvanised tube	0 4½	0 3	0 3 9
72 „ ¼-in. „	0 5¼	0 3	2 9 6
16 in. lead pipe for water-closet pan	0 10	..	0 0 10
3 in. india rubber tubing for ditto	1 1	..	0 1 1
1 ¾-in. self-closing ferrule cock for ditto	7 4	..	0 7 4
1 ¾-in. elbow ferrule, with union joint	2 3½	..	0 2 3½
3 ¾-in. elbow pieces	1 0	..	0 3 0
2 ½-in. „	0 7½	..	0 1 3
7 ¼-in. socket pieces	0 8	..	0 4 8
3 ½-in. „	0 6	..	0 1 6
1 ¾ to ½-in. T-piece	1 2	..	0 1 2
1 ½-in. bib tap	3 4	0 6	0 3 10
1 ¾-in. stop cock	5 2	0 6	0 5 8
1 stop cock case	4 6	1 6	0 6 0
			4 11 10½
Sewerage.			
47 lineal feet of 6-in. earthenware pipe	0 5½	Price varies according to depth.	4 0 1
12 „ 4-in. „	0 4		
7 „ 6 to 6-in. junction pipes	1 6		
2 „ 6-in. bend pipe	1 6		
1 „ 4-in. bend pipe	1 0		
5 „ 4 to 6-in. taper pipe	1 4		
3 earthenware sinks	6 0	3 6	1 8 6
2 6-in. bell traps, with earthenware dishes ..	2 6	5 0	0 10 0
1 water-closet pan and fan, with new seat ..	8 6	14 0	1 2 6
1 ash pit filled up and repaved	5 0	..	0 5 0
Additional clay puddle in passage	..	..	0 5 0
Sewerage	..	..	7 11 1
Water	..	..	4 11 10½
Total	..	..	12 2 11½

Third-Class House.—Rental £7 per Annum.

Water Supply.	Net Price.	Price for Fixing.	Total Cost Fixed.
	s. *d.*	*s.* *d.*	£ *s.* *d.*
10 lineal feet of ¾-in. galvanised tube	0 5½	0 3	0 6 10½
14 „ ½-in. „	0 4½	0 3	0 8 9
12 in. of ¾-in. lead pipe for water-closet pan ..	0 10	..	0 0 10
3 in. of india rubber tubing for ditto	1 1	..	0 1 1
1 ¾-in. self-closing ferrule cock for ditto	7 4	..	0 7 4
1 ¾-in. elbow ferrule, with union joint	1 6½	..	0 1 6½
1 ¾-in. „ „	2 3½	..	0 2 3½
1 ¾-in. socket piece	0 8	..	0 0 8
2 ¾-in. elbow pieces	0 7½	..	0 1 3
3 ¾-in. socket pieces	0 6	..	0 1 6
1 ¾-in. bib cock	3 4	0 6	0 3 10
1 ¾-in. stop cock	5 2	0 6	0 5 8
1 ¾-in. stop cock	3 6	0 6	0 4 0
2 stop cock covers..	4 6	1 6	0 12 0
			2 17 7½
Sewerage.			
32 lineal feet of 6-in earthenware pipe	0 5½	Price varies according to depth.	
14 „ 4-in. „	0 4		
1 „ 6-in. syphon	4 6		2 6 7
1 „ 6 to 6-in. junction pipe	1 6		
2 „ 4 to 6-in. taper pipe	1 4		
1 „ 6-in. bend	1 6		
1 kitchen sink	4 6	5 0	0 9 6
1 4-in. bell trap for ditto	1 6	..	0 1 6
1 earthenware sink, basin, and syphon	6 0	3 6	0 9 6
1 water-closet pan and fan, old seat	8 6	8 6	0 17 0
1 6-in. bell trap	2 6	6 0	0 8 6
Waste-pipe to kitchen sink	..	..	0 6 0
Ash pit filled up and repaved	..	..	0 5 0
Sewerage	..	..	5 4 4
Water	..	..	2 17 7½
Total	..	..	8 1 11½

ALNWICK.

Cost of Private or House-Drainage Works.

The cost of house-drainage works necessarily depends, in a great measure, upon the position of the premises drained with regard to the main-sewer; the length of drains required, the depth at which they are laid, and the character of the subsoil.

The following particulars are given as the average cost of house-drainage works in the town named:—

	£	s.	d.
Houses of £40 rental, with one water-closet, cost about .	15	3	3
Houses of £15 rental, do. do. .	7	11	1
Houses of £7 rental, do. do. .	5	4	4

The length of drain to each house in Alnwick, taken on an average of 516 houses, is 25½ yards.

The following list of loans, sanctioned under the Public Health Act (1848), and the Local Government Act (1858), will show to some extent the progress that has been made in carrying out sanitary works in England during the last twelve years:—

		£	s.	d.
1850.	15th June to 31st December . . .	41,665	0	0
1851.	1st January to 31st December . . .	103,706	0	0
1852.	" " . . .	246,470	0	0
1853.	" " . . .	500,740	0	0
1854.	" " . . .	599,893	0	0
1855.	" " . . .	424,126	6	3
1856.	" " . . .	522,703	16	5
1857.	" " . . .	312,612	11	0
1858.	" 1st September . . .	204,261	13	0
		£2,956,178	6	8

Amount of loans sanctioned under the Local Government Act:—

	£	s.	d.
1858, 1st September to 12th August, 1859 . .	260,905	13	0
1859, 12th August to 21st August, 1860 . .	280,259	7	4
1860, 21st August to 1st August, 1861 . . .	356,192	0	0
1861, 1st August to 1st March, 1862 . . .	129,998	0	0
	1,027,355	0	4
	2,956,178	6	8
	1,027,355	0	4
	£3,983,533	7	0

This amount has been borrowed by 178 towns or districts.

Improvement in social and in sanitary matters has made rapid progress of late. Within the last half-century land-drainage and town-sewerage have ripened into sciences. From rude beginnings, insignificant in extent, and often injurious in their effects, they have become of the first importance. The introduction of

machinery to make land-drainage pipes and town-sewerage pipes, gave a forward movement to civilisation. Land, by judicious draining and improved cultivation, is frequently doubled in value, and town-sewerage, with other social regulations, frequently prolong human life from 5 to 50 per cent. as compared with previous rates in the same districts; and, within my own knowledge, house property throughout a whole town is reputed to have been increased 25 per cent. in value by such works. Agues and typhoid fevers are reduced or entirely banished. John Howard, by his labours, has shown to the world what could be done for gaols and for criminals; Edwin Chadwick, for town-sewerage; and Florence Nightingale for camps, barracks, and hospitals.

With respect to the beneficial effects of sanitary measures, Sir G. C. Lewis, in moving the Army Estimates, said—"There have been a large number of improvements introduced for the purpose of bettering the moral and sanitary condition of the private soldier. In the first place, there has been a great improvement in barracks; and I am happy to say that these improvements in barracks have not been unattended with important results. I will read for the Committee some statistical returns, which I believe to be authentic, and which will show a marked improvement as regards the rate of mortality in the army. The returns are taken for two periods for an average of six years—1830-36, and 1854-60, giving the number per thousand. The annual mortality of the household cavalry from 1830 to 1836 was at the rate of 14 per 1,000; in the latter period it was only 5 per 1,000. In other cavalry it was at the first period 15 per 1,000; in the latter only 6 per 1,000. Royal Artillery, 15 per 1,000 in the first period; in the latter only 7 per 1,000. Foot Guards, 21 per 1,000 in the former period; and only 9 in the latter. The Infantry of the Line, 17 per 1,000 in the former period; and only 8 per 1,000 in the latter. The returns for the colonies, of all forces, for the same periods, showed that for the former—from 1830 to 1836—the mortality at Gibraltar was 22 per 1,000; but, in the latter period, only 9. Malta showed a diminution from 18 to 14 per 1,000; Ionian Islands, from 27 to 9 per 1,000; Bermuda, 35 to 11 per 1,000; Canada, 20 to 10 per 1,000; Jamaica, from 128 to 17; Ceylon, from 74 to 27. These are great results, and they are owing to the changes made in the sanitary condition of the army."

Since the year 1840 great and beneficial sanitary improvements have been effected in English towns. An annual mortality of 44 in the 1,000 has been reduced to 27, and 30 to 20, and even as low as 15. Human life has more value in England than in any other country in the world—entirely due to better sanitary arrangements.

It has been said, "as are the people so will be the government," but my experience leads me to the conclusion that bad government necessarily makes a bad people. Temptation is the parent of vice, and opportunity the broad road leading to destruction. A little leaven of evil leavens the whole mass. Lord Shaftesbury, through the entire of his most valuable life, has

appreciated the facts stated, and has devoted himself to teaching, by example and by precept, to preventing as well as to reforming. His "Common Lodging-Houses Act" has probably done more good than any other law of modern times, by removing temptation; and, therefore, preventing evil. Before the passing of this Act there was no check to vice in its most disgusting forms. I indicate that which I have seen, and cannot, consistently with the decencies of society, openly describe. I only say that our civilisation resembled those volcanic regions where the internal fires of destruction made the earth tremble beneath the feet of the dwellers on the treacherous surface—a sudden outbreak might at any time take place, and overwhelm all in ruin.

Social improvement must begin in the upper circles of society, that it may descend in precept, and be enforced by example. Our own good Queen Victoria understands this. The great and wise Prince we have recently lost, and whom we so deeply mourn, fully understood this. The deep-thinking, far-seeing ruler, who sits on the Imperial throne of France, appreciates the fact. In the International Exhibition of 1851 the model cottages of Prince Albert probably worked more human good, by encouraging home improvements, than all the glitter of precious stones, the wealth of jewellery, and the subtle refinements of art then exhibited. The poor are utterly powerless to help themselves in matters of sanitary improvement. They cannot build their own houses, but must inhabit such as are provided by others. They cannot make laws, neither can they administer such as are made. If, however, the laws are wise, they receive the benefits; if otherwise, they suffer. Social science, as it is termed, must be administered by the State, and this Lord Brougham fully understands. Freedom is a glorious thing, but licence to initiate and work evil against the general body of society for private gain, is neither a safe nor a desirable state of freedom. A state which can tolerate cesspools, beerhouses, gin-palaces, and can license dancing-saloons, must bear with vice, crime, lunacy, and pauperism in excess.

Wise Imperial laws are required, and honest and intellectual administration nationally and locally to secure sanitary progress, and the greatest amount of political contentment, commercial prosperity, health and social comfort to a nation.

STATEMENT *showing the Population, Number of Houses, Length of Sewers, Number of Manholes, Lampholes, and Gullies, and the Total Cost of the Public Sewerage Works in the several Towns named; together with the amount, and Rate in the £ required per Annum to Repay the Principal and Interest in Thirty Years.*

Works Devised and Completed by ROBERT RAWLINSON, Civil Engineer.

TOWN.	Population.	Number of Houses.	Total Length of Sewers.	Number of Manholes.	Number of Lampholes.	Number of Gullies.	TOTAL COST OF WORKS.			AMOUNT PER ANNUM TO REPAY PRINCIPAL AND INTEREST IN THIRTY YEARS.						
							Amount.	Per House.	Per Head.	Total.	Per House.	Per Head.	Rate in the £ per ann.			
			Yards.				£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.			
Alnwick ..	7,016	947	11,132	54	28	140	4,327 18 10	4 11 4	0 12 4	250 5 10	0 5 3	0 0 8½	0 0 5			
Berwick ..	10,067	1,451	7,995	40	51	128	5,649 1 4	3 17 10	0 11 3	326 14 0	0 4 5½	0 0 7½	0 0 3½			
Carlisle ..	26,310	4,113	24,079	131	99	366	23,310 6 7	5 13 4	0 17 8	1,348 2 3	0 6 6½	0 1 0½	0 0 6			
Chorley ..	12,684	2,337	13,205	79	47	282	10,546 4 7	4 10 3	0 16 8	609 19 8	0 5 2½	0 0 11½	0 0 6			
Lancaster	14,604	2,698	12,820	126	118	288	9,245 5 7	3 8 6	0 12 8	534 13 9	0 3 11½	0 0 8½	0 0 4½			
Morpeth ..	4,096	580	7,171	22	..	82	2,720 0 9	4 13 9	0 13 3	157 6 2	0 5 3½	0 0 9	0 0 6			
Ormskirk	5,548	942	6,839	28	..	72	2,982 8 7	3 3 4	0 10 9	172 9 8	0 3 7½	0 0 7½	0 0 4			
Penrith ..	6,668	1,344	7,152	15	99	48	3,109 0 0	2 2 11	0 9 4	179 16 1	0 2 5½	0 0 6½	0 0 3			
Tynemouth	29,170	4,478	17,871	122	154	559	12,404 18 5	2 15 4	0 8 6	717 8 5	0 3 2	0 0 6	0 0 5			
Worksop ..	7,020	1,567	12,429	81	48	136	5,871 19 7	3 14 11	0 16 9	339 12 0	0 4 4	0 0 11½	0 0 6			
TOTALS..	123,183	20,457	120,693	698	644	2,101	80,168 3 3	..	..	4,636 7 10						
AVERAGES	..	..	..	..	..	..	..	3 18 4½	0 13 0	..	0 4 6½ Nearly.	0 0 9 Nearly.	0 0 5 Nearly.			

Average Length of Main Sewer per House = 5·9 yards.

N.B.—Population to Houses about six to one; Private Works, such as house-drains, yard-sinks, soil-pans, &c., cost about equal rates to the above; that is, it is found from experience that the cost of private works of drainage, and of Water Supply Fittings, is about equal to the cost of Public Works of Sewerage and Water Supply.

PARTICULARS OF SEWERS AS EXECUTED IN THE CITY AND TOWNS NAMED.

	Depth to invert of sewer.	Thickness of Brickwork.	Number of bricks per lineal yard.	AVERAGE COST OF SEWERS PER LINEAL YARD.																	
				Birmingham.			Buxton (in Rock).			Carlisle.			Chorley.			Tynemouth.			West Ham.			Worksop.		
BRICK SEWERS—	Ft. In.	Ft. In.		£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.
4 ft. 6 in. by 3 ft. 0 in.	10 0	0 9	432	1	11	6	—			—			—			—			2	3	3	—		
3 ft. 9 in. by 2 ft. 6 in.	10 0	0 9	384	1	8	0	—			1	3	6	1	14	2	—			1	18	1	—		
3 ft. 0 in. by 2 ft. 0 in.	10 0	0 9	304	1	6	0	—			1	2	6	1	5	5	—			1	8	8	—		
2 ft. 3 in. by 1 ft. 6 in.	10 0	0 9	248	0	19	0	—			0	18	6	1	4	8	1	5	6	1	3	9	0	19	9
1 ft. 6 in. diameter ..	10 0	0 9	208	0	18	0	—			0	16	0	0	17	6	—			—			—		
3 ft. 9 in. by 2 ft. 6 in.	10 0	0 4½	172	0	17	0	—			—			—			—			—			—		
3 ft. 0 in. by 2 ft. 0 in.	10 0	0 4½	136	0	16	0	—			0	17	6	—			—			0	19	8	—		
2 ft. 3 in. by 1 ft. 6 in.	10 0	0 4½	112	0	12	0	—			0	15	0	0	11	10	0	18	6	0	17	6	0	13	8
1 ft. 6 in. diameter ..	10 0	0 4½	88	0	10	0	—			0	14	0	0	10	11	—			—			—		
EARTHENWARE PIPE SEWERS																					
15 inches diameter ..	10 0	—	—	0	9	4	0	11	3	0	9	6	0	9	10	0	9	2	0	11	10	0	5	9
12 „ „ ..	10 0	—	—	0	7	8	0	10	4	0	7	9	0	8	2	0	7	5	0	9	4	0	4	6
9 „ „ ..	10 0	—	—	0	6	5	0	9	0	0	5	9	0	5	4	0	5	7	0	7	3	0	3	9

QUESTIONS AND ANSWERS RELATIVE TO SEWERAGE WORKS IN THE TOWNS NAMED. MARCH, 1862.

QUESTIONS.	ALNWICK.	BERWICK-ON-TWEED.	BUXTON.	CARLISLE.	LANCASTER.	WORTHING.
What is the average annual expenditure incurred below the surface of the streets, in cleansing the sewers?	Nothing.	From £10 to £12.	Nothing has been expended.	None.	£4 in four years or £1 per annum.	Nothing. Works executed in 1854.
The number of sewers choked per annum, if any, and the causes of stoppage?	About 20 house-drains per annum. Sand, dish-cloths, and sticks.	Four or five, from offals of animals, ashes, sand, gravel, &c.	None.	Not more than 2 or 3 per ann. in 9-inch pipe sewers owing to flat gradients and backing up of floods. Direct stoppages are caused by improper substances being passed into the drains.	Average five at blank ends. Main sewers never stopped.	None.
Have you any complaints of sewage injuriously affecting fish in the river or stream into which it is passed?	No.	No.	No.	No. Any complaints on this head have been in consequence of an overflow from the sleeper dipping tanks of a railway company passing into the sewers. Waste creosote.	No.	The sewage does not go into a river or stream, but out to sea.
Average annual cost of flushing sewers, if any?	£2 per annum.	Flushed occasionally by the Surveyor or his assistant but at no additional cost to the Board.	They have only been flushed once during the last year.	Water given by Water Company. Flushing and maintenance of sluices attended to by scavengers.	£5 (labour only.)	About £13.
Do the sewers generally serve the purposes intended?	Yes, if properly used.	Yes.	The main sewers are all in good order and work well.	Yes.	Yes.	Yes.

DISCUSSION.

Dr. STENHOUSE, F.R.S., had listened with great pleasure to Mr. Rawlinson's able paper, but would not presume to offer an opinion upon the engineering part of the subject. There was one question, however, in which he had taken great interest, that was as to the use of charcoal air-filters for ventilating sewers. It was towards the close of the year 1853 that he first directed attention to the subject of charcoal in connection with the ventilation of impure atmospheres, and at that time he found that the opinions then prevalent with regard to the properties of that agent were in many respects very erroneous. Charcoal was generally represented to be an antiseptic, whereas he found the contrary was the case—that instead of preventing decomposition it was an agent in promoting it, from its capability of absorbing large quantities of gases. He also found that the charcoal would operate for almost any length of time, because it was not acted upon by the gases with which it came into contact. The properties of charcoal when employed for these purposes were first illustrated by its employment in the form of respirators, for when a charcoal respirator was placed over the mouth it was found that a person could breathe noxious gases for some time without injury. The atmospheric air passed through the charcoal, but the poisonous gases were retained and gradually oxidised. Dr. Stenhouse exhibited an apparatus composed of charcoal fixed between perforated zinc plates, which he had employed in the ventilation of public courts and rooms, and which he said had been used with excellent effect in the courts of the Guildhall and Mansion-house, as well as elsewhere. The apparatus had been in operation seven years in the justice room at the Mansion-house, and during that period the charcoal had been changed only once. A few years afterwards that plan, with some modifications, was adopted by Mr. Rawlinson, Dr. Letheby, and Mr. Haywood for the ventilation of sewers. He was happy to say the subject was beginning to attract general attention, and he believed in the course of a few years charcoal ventilation would become almost universal.

Mr. RAWLINSON called attention to one of the charcoal boxes of the description used by him in the sewers at West Ham. Since the first application of the system he had thought it expedient to have the charcoal broken into smaller pieces than he had first employed, and when this was done its action was much more effectual.

Mr. HAYWOOD. There was a subject to which he would allude—that was the application of charcoal, as an agent for the ventilation of sewers. He believed the priority of that application was due to Mr. Rawlinson, and he had great pleasure in stating that fact. In the reports of Dr. Letheby and himself, as to the application of charcoal, he was sure that no fact had been concealed, but there was at present great difficulty in ascertaining the results of that experiment. The prevention of the escape of effluvium into the

atmosphere above the sewers was a well-known result, and the deodorising properties of charcoal were also well known; but the question to be considered was, what would be the ultimate effects within the sewers? Would it or would it not intercept the necessary action of the atmosphere? Would it or would it not, in the long run, render the atmosphere of the sewers so deadly that men on entering them would be struck down suddenly, as had been the case in a recent instance? On that subject he was unable to give an opinion, but these questions had occurred to his mind. His present impression was that the plan could be beneficially applied as regarded preventing the escape of effluvium from the sewers, but whether or not it would result in rendering the sewers more deadly internally he was not at present able to say.

The CHAIRMAN said the time having arrived for bringing the meeting to a close, he would only say a few words. In the first place he must compliment Mr. Rawlinson upon the very able paper he had given them, which if placed in the hands of people in various parts of the country would give them information of great value. As far as he was concerned he would express generally his sense of the extreme value of perfect drainage and ventilation in all towns and cities; but he looked at the question rather in its agricultural bearings; while, on the one hand, they took care of the health of the people, they must, on the other hand, provide for their being cheaply and well fed, and he must say he hoped the time would come, as he had no doubt it would, when these valuable matters would be employed to a large extent in fertilising the land, which was exhausted by the products taken from it. He begged to move a vote of thanks to Mr. Rawlinson for his valuable paper.

The vote of thanks was then passed.

CHARCOAL AIR FILTER FOR THE VENTILATION AND DISINFECTION OF SEWERS.

By JOHN STENHOUSE, LL.D., F.R.S.

(JOURNAL OF THE SOCIETY OF ARTS, *June 14th*, 1861.)

When we consider that the sewers of London, pervading as they do every part of the metropolis, extend to some 1,500 miles, and that almost every house is more or less intimately connected with them, it is plain that their influence, in a sanitary point of view, cannot readily be over-estimated.

Till within the last few years, the ventilators for the sewers were reduced to as small a number as possible, and always placed in the centres of the streets, on account of the disagreeable and dangerous effluvia which, especially in warm weather, these air-holes were too apt to emit. At present, however, these air-holes may be increased to any extent, and placed in any situation; for since the application of the charcoal air-filters to the ventilating shafts of the sewers, the effluvia and deleterious gases are effectually arrested and destroyed, by being subjected to a species of low combustion, which resolves their carbon into carbonic acid, their hydrogen into water, and their nitrogen into ammonia.

The nature and origin of the charcoal air-filter is as follows. It has long been known that the various kinds of animal and vegetable charcoal, especially

when dry, possess the power of absorbing effluvia, and the greater number of gases and vapours. The subject was first investigated by M. Löwitz, a German chemist, who, towards the close of the last century, showed that charcoal might be made to deodorize and disinfect most putrid substances. About seven years ago, it was discovered by Mr. John Turnbull, of Glasgow, that when the bodies of dead animals are covered over with a few inches of powdered charcoal, and exposed to the air, though the bodies rapidly decay, not the slightest disagreeable odour is evolved. This result I verified in 1853, by burying the bodies of a full-grown cat and two rats, in about two inches of charcoal-powder, and keeping them in my laboratory. The bodies of the animals rapidly decayed, but not the slightest odour was perceptible, nor were any injurious consequences experienced by any of the eight or nine persons by whom the laboratory was daily frequented. Towards the close of 1853, my attention was first directed to the deodorizing and disinfecting properties of charcoal, and I was not long in discovering that the views which had been previously entertained regarding the action of charcoal were exceedingly erroneous; for, instead of acting as an antiseptic, and thereby retarding the decay of putrefying substances with which it was in contact, as had been previously supposed, its action was the very reverse of this. Charcoal, therefore, from the considerable amount of condensed oxygen contained within its pores, amounting to between nine and ten volumes, not only absorbs, but rapidly oxidizes the effluvia and miasmata emitted by decaying substances, and resolves them into the simplest combinations they are capable of forming.

All porous substances, such as platinum black, pumice stone, &c., possess the power of condensing gases within their pores.

The porosity of charcoal is much greater than many persons are aware of. Liebig states, in his "Letters on Chemistry," that the pores in a cubic inch of beechwood charcoal must, at the lowest computation, be equal to a surface of 100 square feet.

When reflecting on the wonderful power of charcoal as a deodorizer and disinfectant, as exhibited in the cases already described, where, as we have seen, a layer of charcoal not more than two inches in thickness is capable of absorbing all the miasmata from such an extensive source of corruption as the putrid body of a large animal, it struck me that a thin layer of charcoal powder interposed between wire gauze would be equally effective in preventing the noxious effects which too frequently result from the very minute quantity of putrid infectious matter floating in the air of what are generally known as unhealthy situations.

These considerations led me to construct the so-called charcoal air-filter for the purification of the atmosphere, which was first publicly exhibited and described by me at the Meeting of the Society of Arts, on the 22nd of February, 1854.*

The charcoal air-filter consists of a layer of charcoal in coarse powder, varying in size, according to circumstances, between a small bean and a filbert. The charcoal is placed between two sheets of wire gauze fixed in a frame, and can be readily applied to buildings, to ships, to the air-shafts of sewers, to water-closets, to respirators, and various other purposes. All the impurities in the air are absorbed by the charcoal, so that a current of pure air alone passes through the filter, and in this way pure air may be obtained from exceedingly impure sources. It is plain that perforated zinc, or a framework of coarse wire filled with larger pieces, and a greater thickness of charcoal, may be also employed, whenever the amount of effluvia evolved is very considerable.

Before the close of the year 1854, air-filters or charcoal-ventilators were fitted up both at the Mansion House and Guildhall. They are each of them several feet in diameter, the layer of charcoal being about one-and-a-half inch in thickness. Although six years have elapsed, the charcoal has never required to be renewed, owing to its oxidating power being practically unlimited. Air-filters were soon afterwards largely employed in private houses, in connexion with drains and water-closets particularly, and they were also very successfully

* See *Journal*, vol. ii., p. 245.

applied to the construction of respirators, many thousands of which have ever since been annually manufactured. On the 2nd of March, 1855, I delivered a lecture at the Royal Institution, on the Economical Application of Charcoal to Sanitary Purposes. It was subsequently published by Churchill, and passed through three editions. In it, the preceding and many additional facts were made known to the public.

Some time after the publication of this lecture, Mr. Robert Rawlinson, the eminent engineer, was induced to apply the charcoal filter, in the beginning of the year 1856, to the air-shafts of sewers. The charcoal filters are so arranged, that while the charcoal is kept dry, the whole of the air issuing from the sewer is made to pass through the charcoal, by which all its impurities are retained and destroyed, nothing but pure air passing up into the street. From the extreme porosity of the charcoal it does not sensibly injure the draught of the air-shafts, and by increasing the size of the filters—for instance, by doubling their diameter, or, what is perhaps much better, by adding to their number—any diminution of air-way may be easily prevented. These filters, from their simplicity, are by no means costly in their construction, and, if kept dry, the charcoal never requires to be renewed.

Mr. Rawlinson has hitherto employed tolerably thick single filters placed perpendicularly. I should prefer using two or more thin filters placed at short distances—say two inches—from each other. These thin filters disinfect the air quite as efficiently as a single thick one, and I think they present rather less obstruction to the air. There is this disadvantage also attending the use of the upright filters, that after a time the charcoal is apt to subside a little, and leave an opening at the top, through which a portion of the air may escape. This, however, is easily prevented by placing a bar of wood or metal, from two to three inches broad, right across the upper part of the outside of the filter. When this has been done, even should the charcoal subside for an inch or so at the top of the filter, no air will be able to pass through which has not been disinfected by the charcoal.

Mr. Rawlinson, during the last four years, has applied charcoal air-filters to the ventilation of sewers on a large scale, at West Ham, near London; at Swansea, Worksop, and Buxton, the entire towns; at Brighton partially; at Bowood, the seat of Lord Lansdowne; and at various other places.

In 1858 a very important and able Report on the state of the sewers, and the various means which have been proposed for disinfecting them, was published by Dr. Letheby, Health Officer of the City of London, and Lecturer on Chemistry and Medical Jurisprudence in the Medical College of the London Hospital. After a minute and rigorous examination of the various methods proposed for disinfecting the sewers of London, some of which were enormously expensive, those with bleaching powder and permanganate of soda being estimated to cost from 200,000 to 270,000 pounds for a single year, Dr. Letheby strongly recommended the employment of charcoal air-filters, as infinitely the cheapest and most effective of all the plans which had been proposed. About a year ago, therefore, under Dr. Letheby's directions, Mr. Haywood, the engineer to the City Commissioners of Sewers, commenced applying the charcoal filters to the ventilation of the sewers in Shoreditch, and to many of the adjoining streets, which were well known to suffer more from the sewerage exhalations than almost any of the other districts in London. Mr. Haywood employed tolerably thin horizontal charcoal filters, three or four being placed one above the other on a stalk, with short distances between them, the pieces of charcoal being from one inch to an inch-and-a-half in length, and placed in single layers, while Mr. Rawlinson, as already mentioned, employed single perpendicular filters. In both cases the results have been perfectly satisfactory, as the sewer gases are as effectually destroyed by being subjected to a species of low combustion, as if they had been passed through a red-hot furnace. In this process the charcoal is not acted upon by the gases, but acts upon them, as before stated, causing them to combine with condensed oxygen. The efficiency of the charcoal appears never to diminish, if it is kept dry and its pores are not choked up by dust.

The expense of applying charcoal to the disinfection of the sewers is by no

means considerable, as the first outlay is all that is required. I am informed that the changes rendered necessary by the introduction of charcoal ventilation for the sewers in the extensive district of Shoreditch, have been under £1,000. But had these sewers been originally constructed with a view to the employment of the charcoal ventilators, the expense would have been considerably less.

One great advantage of the charcoal system is, that it enables us to make as many openings into the sewers as we please, and thus prevents any considerable quantity of the gases accumulating at any one point, as they pass up into the filters and are destroyed almost as rapidly as they are formed. Such sewers have, therefore, all the advantages of open drains, without any of their disadvantages. Hence there can never be any considerable pressure on the traps of the house-drains, one of the great disadvantages attendant on the ordinary system of sewers. It is by no means indispensably necessary that the charcoal filters should be placed only in the ventilating-shafts of the sewers. The air-holes in the centre of the streets may be closed, if thought desirable, and the gases conducted by means of wide pipes into charcoal filters, placed at the edges of the pavement, or inserted into the walls of the houses. The lower portions of the lamp-posts enlarged for this purpose, or short pillars, like letter-boxes, either standing at the edges of the pavement, or inserted into the walls of the houses, will answer perfectly well. The only precautions to be observed are, that while the filters shall be sheltered from rain and moisture, free access shall be given to the air.

In conclusion I may state, that for the last six years I have strongly recommended that charcoal air-filters should be applied to all house-drains, sinks, and water-closets.

Special Application of the Filters to Water-closets.

Every water-closet, in my opinion, ought to be furnished with a subsidiary pipe branching off from the main pipe, a little below the valve of the closet. This subsidiary pipe should be carried a few feet above the seat of the closet; and its extremity, which should be open, with the exception of a few wires stretched across it, merely to prevent the charcoal falling into it, should terminate in a charcoal filter six or eight inches thick, into which it should penetrate to the depth of two or three inches, so as, in fact, to be enclosed by a good body of charcoal. Under such an arrangement as this, no foul gases can penetrate into the closet, but will be retained and destroyed by the charcoal, into which they naturally flow, as in this direction scarcely any resistance is offered to their passage; whereas, in almost all water-closets as hitherto constructed, every time that the handle is drawn up the water which descends necessarily forces a quantity of foul air into the closet, and this foul air not unfrequently passes from the closet into the other apartments of the house.

From the preceding statements it is plain that the oxygen contained in the air of the atmosphere is by far the cheapest and most effective deodorizing and disinfecting agent with which we are acquainted, and that the usefulness of the charcoal air-filter consists in its affording a safe and advantageous means of applying atmospheric air to disinfecting purposes.

I think it but justice to myself to state that I have no pecuniary interest in the charcoal air-filter. Though strongly urged to do so, I refrained from securing it by patent, on the grounds that inventions for the prevention of disease and death ought to be sold at the lowest possible price; and should not, therefore, be encumbered with the expense and restrictions attendant upon patent rights.

Dr. Letheby, in a letter to Dr. Stenhouse, dated Dec. 11, 1860, says:—"In reply to your question, as to the efficacy of the charcoal ventilators which have been put down in the City of London for the ventilation of the sewers, I can give you a satisfactory account as far as our experience has yet gone.

"As you are aware, in my Report on the Ventilation of Sewers, in September, 1858, I recommended that an experiment should be tried on a large scale with the charcoal, as a means of destroying the noxious gases which, in their passage from the sewers into the public way, were so constantly a source of annoyance

and danger. Relying on the practical facts which you had already made public, as to the powerful disinfecting action of charcoal, I had no hesitation in recommending its use to the Commissioners of Sewers of this City. Acting on this advice, their engineer, Mr. Haywood, put a large district of the City under treatment. He selected the worst district in his jurisdiction—namely, the eastern division of the metropolis; a locality densely populated and inhabited by a very poor class of persons. The area of the experiment is about fifty acres; it has about seventeen hundred houses and 14,500 inhabitants. It is completely isolated, and every opening for ventilation has been provided with a charcoal air-filter. In this way 103 filters have been put down; and although the sewage of the district is extremely bad, yet no unpleasant effects have been observed, either in the atmosphere of the sewers or on the outside of the ventilators. No hindrance has been offered to ventilation, so that the men can enter the sewers as usual, and the air-filters have completely arrested the flow outwards of the foul gases, so that no offence or annoyance is now observed, except at the gully openings, which have not been provided with charcoal filters. The experiment has been progressing during the whole of the last summer; and although the season has not been so warm as usual, yet the results are sufficiently satisfactory to warrant us in expecting the most complete success.

"I may further add that one of the charcoal ventilators was put up about two years ago, in a locality where the escape of the sewer-gases had been the source of great annoyance and injury to health; and, notwithstanding that it has been in action for two years, yet it is still as perfect as ever, nothing having been done to it during the whole of that time. It has acted most efficiently in the destruction of the noxious gases.

"I am of opinion, from all this, that the employment of your charcoal air-filters will be found of the greatest service in every large town where the sewers must be ventilated."

Mr. William Haywood, Engineer to the City of London Commissioners of Sewers, gives a similarly favourable opinion.

Mr. Robert Rawlinson, C.E., says:—"I have applied this mode of sewer ventilation on a large scale at West Ham, near London; at Worksop, at Swansea, and at Buxton (the entire towns); at Brighton partially; at Bowood, the seat of Lord Lansdowne, and at other places. I shall never, in future, execute any sewers or drains without the intervention of charcoal-boxes to burn off the gases at the points of outlet.

"The entire system of sewers in Worksop is fully ventilated by special arrangements for this purpose, at fifty-one places, and these include all upper ends of sewers.

"There are side-chambers having screens of charcoal intervening, through which any sewer-gases must unceasingly flow; and Dr. Stenhouse has proved that such gases are oxidized by contact with the charcoal, so as to render them innoxious.

"The process is silently carried on, continuously, and at very little cost. A few shillings per annum to renew any charcoal which has become wet, and to cleanse out the ventilating-shafts from road dirt, which may have worked through the surface-grates, by the road traffic above, is all that will be required.

"Up to this time, I have put in use upwards of four hundred charcoal ventilators in sewers executed, and shall continue to use them in future. No sewer should be allowed to be without adequate means for ventilation, and most certainly no ventilator should be without the arrangement of charcoal proposed by Dr. Stenhouse."

P.S.—The London sewers are large, and, for the most part, flat-bottomed, and water-closets are exclusively used, so that the sewage is exceptionally strong, and the flow is sluggish; here special precautions in disinfecting sewage-gases are necessary: but in smaller towns, having small circular sewers, along which there is a quick flow and no deposit, the ventilators may be open, when it will be found that full ventilation—as recommended in the printed suggestions—will so dilute any sewage-gases as to prevent nuisance, even though charcoal is not used.

WINDSOR CASTLE.

REPORT ON THE SEWERAGE, WATER-SUPPLY, VENTILATION, AND SANITARY WORKS.

TO THE RIGHT HONOURABLE WILLIAM COWPER, M.P.,
First Commissioner of Her Majesty's Palaces, Parks, and Public Buildings.

SIR,—On the 27th of January, 1862, I received instructions to "examine and report upon the present condition of the drainage of Windsor Castle."

I immediately put myself in communication with Mr. John Turnbull, Clerk of Works at Windsor Castle, and William Starie, Esq., of the Office of Works. In company with these gentlemen I have examined plans of the sewerage, of the basement, of the several floors, and also of the sewers and of the building external —the outer walls of the Castle. A personal inspection has been made by us, in detail, of the interior of the Castle from the basement to the roofs, visiting every floor and almost every staircase, corridor, and closet within the Castle. We inspected the Royal Mews and the tenement residences connected with the stables; as also the waterworks.

Plans of the sewers, drains, and of the several floors have been examined during the inspection.

Mr. Turnbull, at my request, has furnished the statistical information as to sewers, drains, waterclosets, flushing-tanks, waterworks, fire-prevention apparatus, warming apparatus, ventilation apparatus, and the general arrangements for effectively keeping these works in order.

That I may be enabled to give a more comprehensive idea of the sanitary works undertaken and executed, and the natural and artificial difficulties encountered and overcome, it is necessary briefly, to describe the site on which the Castle stands; and, also, to notice the progressive growth of the Castle from a rude fortress up to its present magnitude.

The site on which the main buildings of the Castle stand is about 100 feet above the river Thames adjoining. The subsoil is chalk.*

The direction of the "slopes" most probably indicates a line of "fault." The steep face or "crag" is to the north and east; the "tail" to the south and west. The valley of the Thames, at

* Chalk absorbs water readily, and is consequently never absolutely "dry;" it is, however, considered a dry subsoil when elevated, as at Windsor Castle.

Windsor, consists of alluvium, a mixture of gravel, sand, silt, and marl, in various proportions. At or near Frogmore (Frog Mere) the bed of chalk on which the Castle stands passes beneath "alluvium."

Chalk forms, comparatively, a dry and healthy subsoil, situate as at Windsor. The elevation of the main platform on which the Castle stands is also an advantage, offering free play for external ventilation, and a good fall for subsoil and surface drainage.

Ancient History.

Edward the Confessor, "for the hope of eternal reward and the remission of all his sins, his father's, mother's, and all his ancestors," granted Wyndleshore (then so called from the winding course of the river Thames), now called Windsor, to the monks at Westminster. William the Conqueror exchanged lands, &c, in Essex for it, and built a house on the hill, which Henry I. converted into a castle, wherein Edward III. was born. About the year 1374, William of Wickham was engaged during a space of fourteen years rebuilding and enlarging Windsor Castle; and from this period to the present date alterations and additions have, from time to time, been executed.

Modern History.

Sir Jeffrey Wyatville commenced the most extensive alterations ever made in Windsor Castle, August 12, 1824. Alterations and additions were continued to the end of the reign of William IV.,* and yet the sewerage and drainage of the Castle-palace remained defective. Cesspools, full of putrid refuse, and drains of the worst description, existed beneath the basements. The means of warming and ventilation were also of the worst possible character. In the royal apartments small casements in the lower parts of the windows could alone be opened.

Soon after the year 1840, Sir James Clark, on learning from Sir Jeffrey Wyatville the very imperfect state of the drainage of Windsor Castle, reported it to the First Commissioner of Woods and Forests, then Lord Lincoln, and requested that the whole subject of the drainage should be thoroughly investigated. Lord Lincoln saw at once the importance of the matter; and after consulting with His Royal Highness the late Prince Consort, caused examination to be made into the sanitary condition of the Castle. The late Sir Henry De la Béche, at the request of Lord Lincoln, reported fully on the sanitary state of Windsor town and Windsor Castle. In consequence of this report, Capt. Vetch, of the Royal Engineers, was commanded to cause plans to be made, and to devise and lay out a system of main sewerage and drainage. Under the immediate superintendence of Mr. Turnbull, the great sanitary works at the Castle, of sewerage, drainage, water-supply, warming, ventilating, &c., have been carried out up to this date.

* From 1824 to the end of the reign of William IV., Parliament voted £750,000, and this sum, plus the regular income, was expended.

Windsor Castle has been fortunate in its sanitary works and arrangements. Capt. Vetch had probably studied the subject of sewerage and drainage more fully than any other person at the date when he reported. The late Prince Consort, with that enlarged and far-seeing vision of intellect which so peculiarly characterized him, readily mastered the question, and encouraged the efforts of those engaged in the work. Mr. James Simpson, civil engineer, revised the water-supply, and brought his long experience and practical knowledge to bear; giving Windsor Castle and its offices a supply of water, for fire and for sanitary purposes, abundant and complete. Mr. John Turnbull, acting under the superior officers of the Board of Works, but also in constant communication with his late Royal Highness the Prince Consort, has, with untiring labour, worked at the progressive changes which have been undertaken to make Windsor Castle as wholesome and as comfortable for domestic uses as it is extensive and regal for State purposes. Sir James Clark has also persistently attended to all necessary sanitary arrangements; so that this class of works in Windsor Castle has received full attention.

Area.

The main building of Windsor Castle, including the courtyards, now cover an area of about twelve statute acres, the basement-floors of the upper ward having an area of about 9,500 square yards, or some two statute acres.

	A.	R.	P.
Area of Windsor Castle on Plan	12	2	3
Terraces not on Plan	1	2	29
East Terrace Garden	3	2	12
Royal Mews	2	1	0

The plan of Windsor Castle is in some respects complex, and such as would not be advisable in new buildings. There is, in parts, too much crowding for the most perfect sanitary arrangements, and also too much isolation for the greatest facility of service and convenience. These defects are due, no doubt, to conditions under which the Castle has grown from a comparatively small place of defence, in a barbarous age, by repeated additions, to the largest Royal residence in Great Britain. Some of the walls now in existence were originally built for purposes of defence, and are consequently of great thickness. They are of chalk-ashlar and rubble wall-stone, set in weak mortar, rendering it difficult, in some instances, to make the spaces and rooms within them available for modern uses. This has, however, been done in a very successful manner. Walls have been underpinned and carried to lower foundations. Flues have been formed, and windows and doors have been cut through, sufficient to give security, ventilation, light, and means of communication.

In the earliest days of Windsor Castle sanitary appliances were of the rudest form. Within the walls there were floors of mud, covered with rushes and litter; and externally, heaps of ordure and refuse, but no sewers nor cesspools.

When chamber-floors were first added to Windsor Castle, square "stacks," or vertical openings like large flues, were formed in the external walls to serve as privies.* The position of some of these places can now be seen in the old walls, but their use, for their original purpose, has gradually been abolished, and they have been adapted to more modern requirements. It is not necessary, for the purpose of this inquiry, to fix a date to the first formation of sewers and cesspools. Sewers of a rude construction, square on section, with rubble side-walls, and uneven in line and gradient, were first formed from internal rooms to the external walls, and for the most part ending immediately outside the buildings. The accumulation of solid and fluid refuse at the base of the Garderobe Tower and at the outer ends of the sewers, in time became obnoxious to sight; and then, first open cesspits, and subsequently covered cesspools, were invented, to store and cover over the foul solids; the sewers only removing occasional overflowings of these most dangerous receptacles of filth;—sewers and cesspools, and their putrid contents, acting with far more deadly energy on the health of those so unfortunate as to breathe the gases liberated within the buildings, than the exposed heaps of refuse of former and ruder periods, when the dung-heaps were washed by the rain, dried by the sun, and the gases were diluted and dispersed by every wind.†

Water-closets were revived and introduced about the beginning of this century; and, as there were no proper sewers, cesspools were formed within the basements to hold the fluids discharged, in the hope that they would be absorbed; but as the refuse in time choked the pores of the subsoil, the cesspools overflowed, when others were made, until, in some cases, the basement of the house became a mass of putrid sewage. And this is the position of many large mansions to this day, both in London and in the country.

General Sanitary Rules.

There are some general rules necessary to be observed in devising entirely new sewerage-works, which cannot now be made applicable to Windsor Castle. I name this, because an approval of work done might otherwise be taken to imply that it would be proper to follow, in other cases, that which exists at Windsor Castle, whereas nothing better could, under existing circumstances, be accomplished.

* The old name for the rude conveniences found in palaces, castles, and mansions, in England formerly, and on the Continent to this day, is "garderobe." The towers in which such conveniences were placed, tier above tier, with a shaft common to the whole, as at King John's Tower and others in Windsor Castle, and as at Langley Castle, are designated as "garderobe towers."

Matthew Paris used the terms "Domicilium necessariorum." The French term "garderobe" is used in old books, as also "privy chamber;" the modern terms are "water-closet" or "closet."

† The dangerous arrangement of sewers, drains, cess-pools, and water-closets beneath and in the Castle, did not escape the notice of the architect; he is said to have remarked, "I hope it is all right; but there will be a terrible stink some day." The abolition of cesspools and construction of proper sewers and drains did not, at the time, engage the professional attention of architects.

As a rule, sewers should not enter any inhabited building, and all drains should commence at the outside walls, and not traverse the floors of the basement.

All water-closets should be in connexion with an external wall, and have a fixed amount of external light and means for unceasing ventilation.

All rooms, to be inhabited, should have external sunlight.

All sewers and drains should have full and free external ventilation, the gases escaping being made to pass through charcoal filters.

Cesspools should not be in existence within or near any dwelling. Manure-tanks can only be allowed for agricultural uses, and these should never have any direct communication with sewers or with house-drains, and should be fully ventilated.

An elevated site (like Windsor Castle) offers a good fall for water and for fluid refuse, but also offers facilities for the rapid upward flow of sewage-gases. It is therefore advisable to break the gradient of any steep sewer or drain at intervals, and cut off by a flap-valve and full ventilation, all chances of gases rising from the lower levels to the buildings and rooms at the highest points.

If sewers and drains traverse the basement of any building, such sewers and drains should be absolutely air-tight within the external walls, and no untrapped internal communication should be allowed with any sewer or drain.

The sub-soil beneath any inhabited building should be dry and sweet, because at all times, when the internal temperature of the air is greater than the external temperature, or than the temperature of the sub-soil and the sewers, the rooms exert a sort of pumping power; so that a foul sub-soil, in which are foul cesspools, sewers, and drains, may give off gases sufficient to contaminate the entire body of air within any building, if such influence is not made impossible and if a full admission of pure air is not provided for.

A natural watercourse should not be inclosed and converted into a sewer, because the volume and flow of water down a brook or rivulet is very irregular, varying as much as 1 to 300; that is, the dry-weather flow of a stream being represented by 1, the wet-weather flow or "flood" may be represented by 300. Any such culvert must, therefore, be vastly in excess of the requirements for removal of sewage, which is almost a fixed volume; the range of variation being very much less than in a natural watercourse. A small brook may serve to drain the surface and sub-soil of several hundred acres of land; a sewer, to remove the entire sewage, surface, and sub-soil water of Windsor Castle, only drains, comparatively, a few acres of land. This distinction is of the utmost importance, but was not considered when the large sewer leading to the Thames was made.*

* An independent sewer-outlet of comparatively small sectional area may be constructed, with storm-water overflows. This sewer may preserve the sewage from extreme dilution, and carry it to the land for agricultural uses, should such mode of sewage-application be at any time adopted.

New Sanitary Works.

Previous to the commencement of the works of sewage and drainage in 1846, the old drains and cesspools were opened out, examined, and their direction, dimensions, and positions, laid down on plans. These plans are now in the Clerk of Works' office.

The old rubble-stone and brick drains have been taken up, as also all tainted refuse and adjoining subsoil, and removed.

All cesspools were opened out, and their foul contents carefully disinfected and emptied. The greater portion of such cesspools have, as in the case of old drains, been removed; and where it was not found practicable to take out the bricks and surrounding earth, such cesspools were emptied, cleansed, disinfected by hot limewash, and filled in with lime concrete.

During the last sixteen years about 6,000 square yards of basement and ground-story floors, out of a total area of about 9,500 square yards, have been taken up for the execution of alterations and repairs, to an extent that gives good reason to believe that not one old cesspool nor old drain remains in Windsor Castle where these works have been executed.

Twenty-three cesspools were removed from the upper ward, and twenty-eight from the middle and lower wards, making 51 in all. These cesspools varied in dimensions from 12 feet by 8 feet and 9 feet deep, to 3 feet diameter and 6 feet deep.

The new sewers are of brickwork, for the most part in cement. The work is true, sound, and perfect.

The new drains are formed with vitreous glazed earthenware pipes, only such as were true in form and perfectly sound having been used. The pipes have socket-joints; they are truly laid, and the joints made good with cement. The drain-pipes within the Castle are laid upon a bed of concrete, composed of chalk and "blue lias lime," and are surrounded and covered to a depth of not less than 6 inches with similar material.

The main drain for Windsor Castle is at a depth of about 30 feet (30 to 35 feet) below the level of the ground-floors, and extends from the North Terrace to the "main-sewer," near "the Long Walk," and a branch of the main-drain extends from the court-yard near the Norman Gate to the East Terrace Garden.

The greatest fall in any drain is 1 in 30; the least gradient, that on the large main, 1 in 460. The gradient of the drain beneath the Castle is 1 in 40. These are good and safe-working gradients.

The work of improvement has been progressive, and is now going on. Money has been voted for some of the works recommended in this report; such, for instance, as the improved outlet to the river from the main-sewer. Water-closets and drains are being ventilated, and the several fixed windows remaining in the Castle will be made to open.

Any wells opened up and found to be foul, have been cleansed by removal of the tainted substance, and renewals made with fresh materials.

Foul sub-soil has in all cases been removed, and fresh gravel or concrete substituted.

In the numerous structural alterations made in Windsor Castle, the old, large, and open chimney-spaces of Mediæval periods have been made good. All new chimney-flues are lined with fire-clay tubes, flushed and grouted in solid.

To prevent smoky chimneys, about seventy of the most troublesome rooms have been ventilated and otherwise improved.

The Quadrangle, or Great Courtyard, was lowered some 3 or 4 feet by the late Sir J. Wyatville. The area is about 2½ acres. This court has been re-formed, drained, gravelled, and paved, so as to preserve an even, clean, and dry surface.

The Cloisters are the property of the dean and canons of Windsor. I did not make any inspection of these, but I was informed that the cloisters had been drained by the late surveyor.

The Military Knights' residences, being private houses, I did not enter to examine them; neither did I inspect the private residences in the Keep, or Round Tower, but I learned that the drainage had been improved.

In these private residences, where the rooms are small, ventilation must, in a great measure, continue to be regulated by the residents themselves.* Perfect sewers and drains, with regular flushing, only constitute parts of a sanitary system necessary to health. Close apartments and rooms may allow of the ripening of contagious fevers, such as scarlatina, if the air is poisoned by over-crowding, and remains stagnant.

Details of Sewers and Drains.

Sewerage and Drainage of Upper Ward, Royal Apartments.

	Length in Yards.
Brick Sewer, 4 feet 6 inches by 3 feet; 9-inch work; executed in 1846	421
Glazed Earthenware pipe drains:—	
9 inches diameter	1,211
6 do. do.	1,629
4 do. do.	1,056

Executed in 1847-8 and 1850.

On this system of drains there are seven man-holes outside the Castle walls, for purposes of inspection, ventilation, and cleansing. There are also seventy down-spouts (stack pipes) and soil-pipes acting as ventilators. There is one ventilating grate at end of main drain on the slopes. The sewers can be entered at three points within the Castle. These entrances are most carefully closed and protected. Two ventilating flues, each 14 inches by 9 inches, lined with earthenware, have recently been carried in the Castle wall from the main sewer to the top of the battlements of the Prince of

* Means of ventilation may, with advantage, be applied to the stairs and passages of these houses and rooms.

Wales's Tower. These flues were recommended to be put in during my inspection, and are acting perfectly.

Sewerage and Drainage of Middle and Lower Wards (exclusive of the Cloisters).

	Length in Yards.
Glazed earthenware pipe drains:—	
12 inches diameter	94
9 do. do.	584
6 do. do.	748
4 do. do.	312
Brick Sewer	120

Executed in the year 1850.

The drainage of the Royal Mews was commenced in the year 1850, and completed in 1860.

	Length in Yards.
Brick Sewers, old, but adopted:—	
18 inches diameter	229
12 do. do.	382
9 do. do.	282
Glazed earthenware pipe drains:—	
18 inches diameter	483
12 do. do.	173
9 do. do.	314
6 do. do.	928
4 do. do.	342

Sewerage in Home Park, commenced in the year 1845.

Main Sewer, 7 feet 6 inches by 5 feet 4 inches ..	1,617
„ 3 feet 2 inches by 2 feet 2 inches ..	268
„ 3 feet diameter	342
„ 2 feet 2 inches diameter	313

On the main sewers there are eighty ventilating gratings, and flap over sewer end, to prevent any flow of sewage gases up to the Castle.

Windsor Castle Closets, &c.

The Royal Residence, Upper Ward.

Water-closets in Upper Ward	85

Forty-two of these closets have 2-inch flushing valves and pipes from cisterns to traps; thirty-one have the soil-pipes ventilated; nineteen additional are ventilated by the rain-water down-spouts (stack pipes); and twenty-six have Watson's patent double-action syphon ventilators. There are also forty-one of these syphon ventilators to the corridors, staircases, and passages. There are ten external water-closets for servants, and four urinals.

The floors of the external water-closets and urinals are laid with glazed earthenware tiles, and the walls are covered with similar tiles to a height of 5 feet. These places are washed with a fire-hose and mops every morning. M'Dougall's disinfecting powder is used as required.

Middle Ward.

Water-closets 29

Eighteen of these closets have 2-inch flushing valves and pipes from cisterns to traps; ten have the lead soil-pipes ventilated; five are ventilated by rain-water pipes (stack pipes); and eight are exterior servants' water-closets.

There are five urinals, all external, arranged and managed as previously described.

Lower Ward (exclusive of the Cloisters).

Water-closets 25

These have syphon traps; two are ventilated by rain-water pipes, and one has a Watson's ventilator.

The means of flushing the syphon traps of the water-closets is new, having been invented and applied by Mr. Turnbull; and, so far as I know, is peculiar to Windsor Castle. The abundant supply of water enables this form of application to be made. The effect is most beneficial.

In arranging, constructing, and fixing the water-closets, great care has been taken to test all the "stack pipes" by hydraulic pressure. The leaden pipe has been placed vertical, and then filled with water, so as most effectually to prove the soundness of the pipe and its joints before use.

Old and defective forms of water-closets have been removed, and the best and most perfect forms substituted.

Warming and Ventilation.

The Castle is warmed on Price's system, which is simple in construction, safe in use, and perfectly cleanly and wholesome; the fresh air being warmed (not burned) by means of an extensive surface of iron warmed by water at a low temperature, 70 to 80 degrees.

Tunnel entrances open at various points where fresh air can enter, free from any source of contamination, and pass on in a continuous stream to the warming apparatus, where it is heated so as to pass on to the corridors, halls, and rooms, at a temperature of about 65 degrees Fahrenheit.

The tunnels and fresh-air passages are preserved perfectly clean, the side-walls and arches being annually whitewashed.

The existing arrangements for warming and ventilating Windsor Castle were commenced in the year 1842. The apparatus most recently added (1861 and 1862) are in the Lancaster and Winchester Towers.

The numbers and situations of the warming apparatus are as under:—

	Numbers.
Private Apartments	7
State Apartments	6
Norman Tower	1
Round Tower..	1
Henry III. Tower	1
Lancaster Tower	1
Winchester Tower	1
Total	17

Up to the year 1850, means of ventilation by windows in Windsor Castle were very limited and defective. Even in the Royal apartments the upper portions of the windows were fixed; lower casements alone could be opened, so that by far the largest amount of air spaces in the rooms, when they were in use, contained vitiated air, comparatively stagnant. 240 of the top sashes in these windows have been made to open; and 50 of the upper sashes in large windows, which could not be reached by other means, can now be opened, even by a lady, with perfect ease. This is accomplished by the intervention of machinery specially contrived and adapted for this purpose.

It is of the utmost importance that all lofty rooms should have ample means of ventilation at or near the ceiling, and experience demonstrates that no plan is so good, simple, easy, and safe, as windows which can readily be opened.*

Water-Supply.

The supply of water to Windsor Castle is abundant in volume and constant in service.

On the bank of the Thames, to the north of the Castle, a water-wheel was erected by the celebrated engineer, John Smeaton, and recently a steam-engine has been added by Mr. James Simpson, under whose direction the general supply apparatus has been improved, and the distributing apparatus arranged. A complete and effective fire-service exists.

Water, at all times clear and bright, is pumped from wells sunk in the gravel: by a water-wheel, ordinarily, which works night and day, and by the steam-engine, in cases of fire, flood, drought, or frost.

There is a storage reservoir situate at the Cranbourn Tower (*Crane Bourn*, or stream), Great Park, some 140 feet above the level of Windsor Castle Quadrangle. This reservoir contains one million gallons of water, and is maintained full, so as to be ready for use in case of fire.

The wells at the waterworks are, one of five feet diameter and two of four feet diameter. They are lined with cast-iron cylinders to a depth of 25 feet, so as to exclude surrounding subsoil water, and

* Flues do not ventilate rooms sufficiently. The air in single flues is frequently stagnant, or has a reverse action—a "down-draught."

are open at the bottom. By this arrangement, this portion of the valley of the Thames becomes a natural filter-bed, 25 feet in thickness.

There is one set of three-throw pumps, 8½ inches diameter, and 18 inches stroke, and two sets of three-throw pumps 6½ inches diameter and 12 inches stroke. The ordinary speed worked is 12 strokes per minute. The volume of water forced to the Castle is about 8,200 gallons per hour, or nearly 200,000 gallons per day.

The waterworks supply Windsor Castle, Royal Mews, Frogmore, Royal kitchen gardens, the Shaw Farm, and Dairy-farm homestead, as also the lodges in the Home Park.

The steam-engine is 16 horse-power. The rising main, from the pumps to the storage reservoirs at Cranbourn Tower, is 10 inches diameter. This main passes through the Castle Quadrangle; 7-inch branch mains pass to the roads, court-yards, and terraces. There are branch pipes, 5 inches and 4 inches diameter, carried into the Castle, on which fire-valves are fitted with keys, hose, hand-pipes, and nozzles complete.

There are 95 stations in the interior of Windsor Castle, and 206 fire-valves provided, with apparatus complete.

There are 33 hydrants, with 2½-inch screw pipe outlets, and boxes complete, on the roads, in the courts, yards, and on the terraces.

The fire-services within Windsor Castle are fixed in the halls, on the staircases, and in corridors and passages, at such distances as to allow of any two commanding all the rooms and spaces betwixt them.

There is a working engineer regularly employed, whose duty it is to clean, repair, and maintain the working parts of the machinery in order, both of the water-wheel and of the steam-engine, as also the valves and hydrants.

There is a turncock to attend to the distribution of the water, and to regulate the supply, from time to time, to the various points as required.

For flushing the drains a man is placed at each sluice-valve, so as to insure a simultaneous discharge of water.

There is a fire brigade, provided with a uniform, composed of ten of the workmen employed at the Castle. They are drilled once each month, going round all the stations to see that every part of the apparatus is in working order.

Royal Mews.

The Royal Mews is fully sewered and drained. The sewers are regularly flushed, and all the drains are fully ventilated.

There are forty water-closets in connexion with the Royal Mews.

There is full light by windows, and ample ventilation by windows and by air chambers to all the W.C.'s.

There are thirteen of Watson's ventilators in the passages of servants' apartments.

There are twenty-two of Watson's ventilators in the stables and riding-house.

N.B.—Watson's ventilators are upon the double-action syphon principle, a continuous current of air being established.

The clerk of works informed me that every complaint of stench is brought under his notice, and that to the best of his recollection, no complaints had been made of the sewers and drains. At times there have been complaints as to sinks and W.C.'s; but on investigation the causes were found to have arisen from improper use or abuse of these apparatus. In all such cases the places are cleaned, and any defects remedied at once.

The servants' residences at the Royal Mews are not on a good plan. There is a block building, several stories in height, having an internal passage longitudinally on each floor. This passage is reached by common stairs at each end, and is also lighted by windows similarly placed.

The separate residences are on each side of these passages, having doors opening opposite. For purposes of ventilation there are open gratings in the upper floors of the passages, giving communication betwixt one passage and the other.

The washhouses are small, and the steam from the boiling water ascends into the passages, to the annoyance of the residents. (This will be at once altered.)

The barrack-like arrangement described has many inconveniences, and no advantages but that of economy of surface-space. Any noise in the common passage disturbs several families, and this tends to disagreement.

As shown in the details given, all possible care has been taken in sanitary works to improve the building; but it never can be other than a bad plan made the best of.

Detached washhouses for the use of the residents in these block tenements may easily be provided; and by removing the heat, steam, and slop from the main building a great sanitary good would be effected.

Flushing Tanks.

The arrangements at Windsor Castle for flushing sewers and drains are of the most complete kind. The sites on which the tanks are placed command the upper ends of the sewers and drains, and the volume of water at command is ample, and the means to liberate it well devised.

	Gallons at command.
Tank in courtyard: Norman Gate	8,100
This water is discharged through a sluice-valve 10 inches in diameter.	
North Terrace (4-inch sluice-valve)	1,780
East Terrace (12-inch sluice-valve)	35,341
Summit of Brunswick Tower (4-inch stand-pipe) ..	3,130
Round Tower (3-inch sluice-valve)	1,875
Winchester Tower (3-inch sluice-valve)	350
Total gallons	50,476

Or, about 225 Tons.

There are in addition sixteen sluice-valves on the water-supply mains from 3 inches to 2 inches diameter, opening into branch drains.

At the Royal Mews the arrangements are as under:—

	Gallons at command.
One tank, containing .. .. Four 2-inch sluice-valves.	2,025
One tank, containing .. .. Six 2½-inch sluice-valves.	4,050
One tank, containing .. .. Two 2½-inch sluice-valves.	3,375
One tank, containing .. .. Two 2½-inch sluice-valves.	2,812
One tank, containing .. .. One 3-inch sluice-valve.	625
Making 15 sluice-valves, and a total in gallons of ..	12,887
Or, about 57½ Tons.	

There are, in addition, three sluice-valves from the water mains, 3 and 2 inches diameter, connected with branch drains.

Windsor Castle drains and sewers are flushed every morning.

At Adelaide Terrace, in connexion with the main sewer belonging to the Crown, there is a large flushing tank, on which are placed two "pen-stocks" complete.

This tank is brought into use on alternate days by the sewer man, who has no other employment than to attend to the sewers and preserve them clean. The pen-stocks insure a head of water of 4 feet; and this, when necessary, is brought into use four times within the twenty-four hours.

Water from the river Thames flows into and through the main-sewer of the borough, and thence into and through the Crown sewer.

This flow of water is never less than 18 inches in depth in dry weather, but ordinarily is some 3 feet in depth.

The borough sewer is flushed on alternate days with the Crown sewer, and this insures the main sewers belonging to the Crown being flushed every working day.

Capt. Vetch devised the flushing arrangements as part of his plan, and the numerous additions subsequently made have been in the spirit of the first design. The object aimed at throughout is to remove, immediately, by water, and before any injurious changes of fermentation or putrefaction can take place in the sewage beneath the Castle or in connexion with it, all soil or slop refuse from the drains and sewers to the outlet into the river Thames. This is now accomplished effectively and regularly.

The question of use and utilization of this sewage on meadow lands in the district may be taken up before long. I have no doubt as to the practicability of such plan. A cause of pollution will be removed from the river, and the land will be enriched. A line of conduit may remove the operation to a safe distance from the Castle, at a reasonable cost.

Complaints have been made of nuisances arising from want of proper main-sewerage and efficient house-drainage at certain new houses near Adelaide Terrace, "King's Road." The Cranbourn brook flows into the head of the large flushing-tank, and any sewage discharged into Cranbourn is liable to pass into the flushing-tank, and, at times, during local floods of rain, to be washed through the tank at the lower overflow, and so cause nuisance on the surface. Some of the property in this district is on land belonging to the Woods and Forests Department, and it is highly desirable that proper works of sewerage and drainage should be enforced.

In all districts where the suburbs of a town are extending there is a liability to nuisance from new roads remaining unformed and new streets remaining unsewered.

In such cases new houses are drained either into cesspools, on to the surface, or out and into the nearest watercourse or ditch. This latter appears to be the case at the new houses near Adelaide Terrace.

Remarks.

In making the suggestions and recommendations embodied in this Report I do not wish it to be understood that all the various forms of alterations are required in Windsor Castle. On the contrary, I wish most distinctly to record my opinion, that very little improvement can be added to the sanitary works connected with Windsor Castle. During my inspections I have been extremely gratified to find evidences of thought, ingenuity, and constructive skill in every alteration made during the last fifteen years. The late Prince Consort brought his great artistic taste and knowledge in architectural and in sanitary questions, to aid the indefatigable exertions of the Board of Works and the resident Clerk of Works, in effecting an entire remodelling of the domestic arrangements within Windsor Castle. This Report is necessarily brief, and consequently in some respects imperfect, but it details and indicates a vast amount of work done within a short period, and most of this work is connected directly or indirectly with sanitary improvement.

At this present time I believe that Windsor Castle is the most complete in sanitary works, appliances, and arrangements, of any large building in existence.

The sewerage and drainage are ample and efficient. The volume of water is relatively large, and the quality is as good as water having sixteen degrees of hardness can be. The service is at high pressure and is constant; the points of distribution are numerous, convenient, and in good working order.

There is a distinct fire apparatus and a regularly trained body of firemen. The warming of the Castle is admirably arranged and in perfect condition, and means of ventilation are numerous—in many instances most ingenious, and generally efficient. The question of ventilation is, however, by far the

most difficult to settle in a climate so variable as this of England. Fixed and constant means of ventilation are required to keep up internal motion in the air, and to promote unceasing change; and if outlets and inlets are not judiciously placed, guarded and secreted, they will be tampered with and blocked up. Warmth is constantly obtained, in modern houses and buildings, at the sacrifice of health. Unceasing motion and change in atmospheric air are necessary to healthy respiration. Stagnation is produced by inadequate means of ventilation. The great problem to be solved in internal warming and ventilating arrangements is to have a comfortable warmth of fresh air, neither much above nor much below sixty-five degrees Fahrenheit. A less temperature in rooms containing sinks and water-closets is, however, allowable.

The Castle Court Guard-room, now in course of adaptation and construction, will, in many respects be an improvement. The conveniences (water-closets and urinals) are, however, too much confined, and unless the fullest possible arrangements of a fixed character are provided for ventilation, they will be a cause of nuisance to the inmates of the Guard-room. Places of this sort, used regularly by large numbers of men, should be detached; that is, a divisional wall, having an intervening space, should be provided, and as much open space as the construction of the roof will allow should be made at the highest points. The place is not capable of being fully lighted, except by artificial means.

Recommendations.

The new works, alterations, and appliances recommended are as herein detailed:—

The introduction of charcoal air-filters at all available points to disinfect sewage gases.

Covering the portion of main sewer now open near its outlet into the Thames, and forming a low-water outlet, by means of cast-iron pipes continued from the sewer to below the surface level of the water in dry weather. This alteration will abolish a nuisance which now exists near the private road on the margin of the river. This work has been estimated and provided for, and will be done immediately.

The main branch sewers from the Castle to the main sewer to be isolated and ventilated.

The steep gradient, which is now continuous, to be broken, and a flap to be placed at the end of the upper sewer, with a vertical shaft, and double ventilation. This arrangement detaches the lower levels from the buildings on the higher levels, and diminishes the risks of gaseous contaminations.

All branch drains to have means of ventilation outside the main walls of the Castle, and, where practicable, a flap-cover to prevent in-draughts from the drains and sewers.

All sink-pipes, where practicable, to have a broken connexion with drains outside the main walls. This arrangement is made by

forming a small shaft from the drain, and allowing the sink-pipe to enter. The shaft from the drain to have means of external ventilation.

All water-closets and rooms in which sinks are placed and used, to have means of permanent ventilation, which can neither be seen nor be tampered with. An area of twelve square inches communication with the external air ought to be the least space allowable. A narrow slit-like opening will be better than a square or circular opening, as the area acted upon will be longer, and direct draughts less felt. If rooms in which water-closets and sinks are placed depend for ventilation on windows, which can be opened or shut at pleasure, such windows will frequently be closed, to the exclusion of all means of change of air, other than from or into the adjoining corridors and rooms.

Disinfectants are requisite at servants' urinals and closets, as water alone will not preserve such places free from taint.

All closets and places used for storing fuel, wood, coal, and coke, should be fireproof, and have means for full external ventilation. Materials liable to spontaneous combustion, such as lamp-oil, grease, turpentine, waste, and dirty rags used in cleaning lamps, &c., should be placed in vessels of iron or other metal, and be removed at short intervals. But all rooms in which lamps are cleaned and trimmed should be fireproof and isolated.

A considerable portion of Windsor Castle has been made fireproof, so far as is practicable; but one secure precaution against the possibility of any extensive conflagration will be to break the Castle up into sections by fireproof divisional walls from the basement through the roofs, or by double iron or other metal doors of communication. Such arrangements can be carried out without in the least diminishing any domestic conveniences or comforts. Varnished pine-timber in floors is specially dangerous, and continuous timber floors (or partitions) in corridors and passages, in cases of fire, facilitate rapid means of combustion. If it is not practicable to remove all the timber in corridor floors and partitions, it is possible to break the continuity of such floors and partitions, at intervals, by concrete, so as to prevent flame running along unchecked.

Roof-lights and internal reflectors are sometimes causes of fire. A rough unpolished piece of glass may concentrate the sun's rays, like a lens or "burning-glass." Metal, in contact with pine-wood, may be heated by the sun's rays, in this climate, almost to the point of combustion. Wood so placed becomes in time "dry as tinder," and quite as combustible. A considerable portion of the roof to Windsor Castle is covered with sheet-lead, and during very hot days it may be advisable to water it.

Covering timber with lead is injurious to the timber as tending to rot. An air-tight covering of any material for a roof is liable to act injuriously, just as air-tight doors and windows may be injurious; there must be provision for ventilation, by unceasing change of air, to avoid mischief to health and injury to timber.

In concluding this Report, I beg most respectfully to recommend that complete sets of plans be prepared and indexed for future reference. There are the plans, which have been made from time to time, in detachments, and there is all the information requisite, but not in so clear, complete, and condensed a form as is desirable. It is impossible for any of the present officers to undertake such a work and continue to fulfil their present duties, but they may probably find time to direct and superintend any surveyor or architectural draughtsmen engaged to do such work. Some of the best men in the Ordnance Survey Office may with advantage be employed to make a complete set of plans of Windsor Castle as it now exists,—its sewers, drains, basements, floors, lands, and appurtenances.

POLLUTION OF RIVERS IN ENGLAND.

Read at a Meeting of the Health Department of the Social Science Association, May 23, 1866.

SANITARY science is not a matter of instinct, but of study, trial, and unceasing care. Science must wage continuous war with nature, or men will remain as the brutes. There must be education continued from age to age, or the discoveries of one generation will not avail succeeding generations of men.

Man, in a state of nature, does not attend much to the laws of sanitary science. The noble savage, under a coating of war-paint, is not very choice in his instincts. But war-paint and scalps indicate advances in civilisation—there are types of men existing in lower grades than the one occupied by the Red Indians. The rude tribes of Africa, Australia, India, and of the polar regions, the bog-cabin of Ireland, and the bothy of Scotland, with the potatoes of the one and the "braxey" meat of the other, range, in some respects, even below the Red Indian of North America. The first rise from barbarism seems to lead men to seek warmth by conserving the heat of their own bodies. A tainted atmosphere is the result—disease is contingent. The instinct of a wild beast is absent.

It is interesting to trace the progress of sanitary science.

The savage seeks for means of warmth, with shelter when at rest, paying no attention to the state of the atmosphere around him.

As civilisation advances, the chase of wild animals is conserved to royalty and nobles. The hog is placed under the care of Saxon Gurths.

The Norman baron erected his castle, and about its walls and outside its boundary river, or moat, congregated the cots and huts of his serfs and retainers. Castle and hut corrupted the surface they covered, but did not foul the rivers.

Mediæval towns, with tall houses, narrow streets, overhanging storeys, and unpaved surfaces, were walled in for protection. There were neither sewers, drains, nor scavenging; but rooms, yards, and streets alike were sodden with accumulated filth; surface-wells were tainted, but rivers flowed down in a comparative state of purity. There were emperors, kings, grades of nobility, and

knighthoods, with bishops, and hosts of inferior orders of the priesthood; pomp and ceremony, based on oppression and human misery. Sanitary science was not, however, known even in name, but filth was part of religion. Holy men lived without any change of clothing; they died prematurely of some filth-bred disease; and their bodies were found covered with loathsome parasites, this was, however, set down to their credit, as having lived and died in a state of sanctity.

The prime law of sanitary science is that which instructs men how health shall be secured and prolonged for the greatest numbers.

A pure religion teaches, by precept and by practice, that cleanliness is akin to godliness. A pure city must contain pure houses, and these must shelter pure human bodies, before they can enshrine pure minds.

Sanitary science should precede all other forms of learning in rank and importance. At present, it is known only by name at our universities.

The gradual progress of sanitary science has led to the pollution of rivers, which evil has risen to so great a height, that men ignorant of the results, desire to force society back into one state of mediæval filth, regardless of consequences. There has been a cry for a return to cesspools.

The castle of the Norman baron had its garderobe-tower, and outside the castle walls a mound of excrementitious filth; within there was its unpaved courtyard and rush-covered floor sodden with filth indescribable. Rude doors, rough carpentry, wide chimneys, and tapestried walls gave admission to fresh air, and so life attained to a certain rude strength, which was expended in robbery, oppression, and war.

In towns and in villages there were filth, squalor, misery, and premature death; sweating-sickness, black-death, plague, putrid typhus, and of late cholera. Putrefaction from time to time so corrupted the air, water, and blood, that a moiety of all the inhabitants of an infected district were swept to untimely death, and the survivors lingered in weakness and misery to sink prematurely into their graves.

The first form of improvement in towns consisted of rudely-paved streets—stones unassorted, big and little, laid down at random, which formed a surface that prevented the existence of an actual quagmire, but did not insure much of comfort or of cleanliness to pedestrians. The channel was usually open, and down the centre of the street.

Towns, as inhabited in mediæval times, on the Continent, and even in Great Britain, during the memory of living men, had the surface and subsoil one mass of filth.

The "Wha wants me?" of old Edinburgh was a step in advance, as was also the midnight and morning shower from certain domestic utensils over the footways and streets of other towns. The only scavenger was, however, the sun to dry, and the city shower to wash—of other scavenging there was none.

The first sanitary step in advance led to backdoor-middens and cess-pits, as they prevail now in cities, towns, and villages in Great Britain; something worse on the Continent. Then came cesspools and covered drains, and ultimately rude sewers to remove occasional surface water and the overflowings from non-absorbent cesspools; an absorbent cesspool, as in chalk, at Brighton, and at some other places, with a well for domestic uses adjoining, being considered "perfection," as combining economy of construction and management with utility. There were no sewer-rates, and rivers were not fouled. The local Registrar of Deaths, however, strikes a heavy annual balance in all such places.

Sewers are as ancient as the Cloaca Maxima; and, as indicated in the ruin mounds of Asia, much older. The sewers and drains of ancient Rome certainly polluted the river Tiber. I shall not, however, be surprised to learn that sewage irrigation belonged, in some form or other, to the ancients, as they seem to have "stolen all the ideas of us poor moderns."

Main sewers were not at first formed in England to drain houses, as the common law of England holds that every man shall retain and dispose of his refuse or effete matters, so as not to be any nuisance to his neighbour. Hence the construction of cesspools, one cesspool after another, until the entire site upon which a house stood became honeycombed with cesspools; just as in other parts of the world, Africa and India, for instance, the dead are buried beneath the floor of the hut, and in China are placed on the surface of the ground around the joss-houses, to fester and putrify; contaminating alike the air, the subsoil, and the water.

In Lower India, the Holy Ganges receives the bodies of Hindoos, which cause this form of river pollution. In Bombay there are the Parsee "towers of silence."

About the commencement of this century sanitary science re-invented the modern water-closet; and, with the cheapening and improvement of cast-iron came cast-iron water-pipes and fuller and better supplies of water. Cesspools, when they ceased to absorb as fast as they were filled, overflowed; these overflows were stealthily connected with the main-sewers; and, in time, water-closet, house-sink, and yard-drains were taken direct into the main-sewers. As these necessarily had connexion with streams, brooks, and rivers, pollution of rivers became more general. The law of exclusion of house-drainage from main-sewers was repealed in London, and with the alteration came improvement of the public health, so marked and self-evident as to command attention. The old sewers are, however, large, flat-bottomed, and vertical-sided; they are neither true in line nor in gradient; they receive sewage, but do not regularly transmit it to the outlet; the fluids soak and evaporate, the solids accumulate, putridity sets in, and a scourge of typhus fever now and then is a consequence.

These sewers of deposit prove, nevertheless, to be the cause of an immense advance in town sewering, namely, main sewer ventilation, by which the gases of decomposition are regularly and con-

tinuously diluted. It became necessary to cleanse these rude, uneven, absorbent, flat-bottomed main-sewers by manual labour, and to enable men to enter them and live, ventilation was necessary. This, although an imperfect and rude contrivance, has saved thousands of lives annually in London.

The river Thames has been polluted, but the health of the entire population has been improved, as the Registrar-General's returns show. If human life is most to be considered, and if the greatest amount of human health can only be secured by a pollution or partial pollution of rivers, it will consist with the wisdom of a state to choose that course of procedure which is to secure the greatest amount of comfort to the greatest numbers. This, at present, is not provided for in the common law of England, nor is it in any degree recognised by common law judges. The opinion is acted upon, that no man is to injure his neighbour; that no body nor number of men are to injure the individual. The water of a mill or of a fish-pond, for instance, is not to be contaminated; although thousands enjoy improved health and prolonged life in doing the wrong, and comfort alone in the individual is interfered with. Bentham would have ruled differently. Injunctions lie against sewered towns for fouling mill-streams, or ornamental lakes, or fish-ponds; but for the evil in its most gigantic and worst forms, as in the rivers and streams of Yorkshire and Lancashire, no legal remedy exists. The number of the offenders and the magnitude of the offence set common law at defiance. How shall an injunction be enforced in such cases? The Government has recognised the evil and the difficulty, and has advised Her Majesty the Queen to appoint a Royal Commission to inquire into the pollution of rivers; a first Report on the River Thames having recently been published.

It must ever be interesting and also instructive to study the progress of civilisation. The student may do this in his closet by the aid of observant writers, and by the labours of historians. Closet study is not, however, very reliable; as, for full information, the mind must be instructed through the senses. We must see, feel, smell, and endure some of the miseries resultant from defective sanitary arrangements rightly to comprehend the causes of sweating-sickness and plague. A student of geology cannot find living examples of the huge saurians of the oolites and lias, but he may study every type of life in some part of the globe. The great Pacific Ocean swarms with coralines and sauroidal fish; some island groups produce almost exclusively reptiles; and in the great rivers, swamps, and wastes of Africa and South America, huge Pachydermata and gigantic reptiles abound. The greatest of living creatures, the whale, disports its huge carcase amidst polar ice. Progressive development does not mean progressive growth from one type of life to something higher over the entire surface of the globe at the same time.

Every past type of human life may be seen and studied now. The tribes of Australia and Africa show us man in his most

helpless form. In the East, men live as during the days of Abraham; in China, as when Confucius promulgated his laws; and in India, as when Buddha taught. In Russia, in Spain, and in Southern Italy, we may find representatives of our Middle Ages—countries without road; villages half morass, half forest; towns without pavements, without sewers, without police, and without any form of public or private scavenging. The good old times exist in all their strength and offensiveness; bandits infest the country, filth and fever haunt the villages and towns. The rivers are, however, free from sewage pollution.

In this rude and most imperfect sketch of the progress of sanitary science, I have attempted to show that one form of evil may have supplanted others which were far worse; but I further purpose to indicate, that not only were the sanitary defects of mediæval life the result of a common neglect, but also that our modern sanitary abominations equally result from ignorance, abuse, and neglect of the teachings of true sanitary science.

This may aptly be termed the age of great cities. Trade is massing men in England, until our town population exceeds that of the country.

Trade, commerce, and manufactures fix their greatest centres on the margins of our rivers. Commerce crowds the estuaries, and manufactories line both banks up to the sources. The waters of our abounding streams were first taken for beneficial use; and now, by common neglect, every stream and river on which manufacturing populations have settled, is abused—fouled beyond the power of words to describe. The fable of the goose which laid golden eggs is being repeated; the common law of the land is openly and notoriously broken. As in society, one cut-throat makes a murderer and may be hung, the wholesale murderer is a hero, and gains honour, wealth, and decorations; so with our rivers, an individual may be prosecuted successfully for committing a nuisance, but the wholesale polluters of what were at one time our most beautiful streams and rivers, openly and continuously set common law and common decency at defiance, by polluting rivers wholesale, and gain wealth thereby, and the honour of a seat in the National Legislative Chamber, to assist in making new laws, and in supporting those they persistently and continuously break. Is the poet the prophet? Will the thoughts of men be widened? Shall we in time learn that law-breakers should not be law-makers and law administrators.

The atmosphere over our great towns is darkened by smoke, which may be prevented; our rivers are polluted by abuse in many forms. In both cases prevention will be true economy, and that which is the best for the community will be found to be the best also for the individual; civilisation is a complex piece of machinery, and requires unceasing intelligent care to keep it in order. We cannot turn the dial-hand of Time back, but must move with its motion. We must, however, avoid the suicide's fate, and strive to make life better, fuller, holier, and cleanlier than in the days when

our rivers were pure and bright, because no local abuse existed. The creation of wealth should mean the creation of additional means of comfort and health to the populations which create the wealth, or it means premature ruin and ultimate decay. We must see that we realise the vision of the poet, and, by wise legislative care, make it—

"Better fifty years of Europe than a cycle of Cathay."

Men now live longer and faster than formerly. A man, in these days of steam and electricity, may do more, see more, know more, and, if wise, enjoy more, than generations of his ancestors; but he must learn, understand, and obey the laws of sanitary science, which will teach him to utilise waste-products, and so restore our streams and rivers to their ancient state of purity and beauty.

ADDRESS ON HEALTH.

At the Newcastle-upon-Tyne Congress of the Social Science Association, September, 1870.

THE programme states that this Department considers the various questions relating to the Public Health, and collects statistical evidence of the relative healthiness of different localities, of different industrial occupations, and generally, of the influences of external circumstances in the production of health or disease.

The special questions named for discussion are:—

"What is the best method of disposing of sewage and excreta?

"What modifications are desirable in existing sanitary laws and administration?

"What legislative measures ought to be taken to prevent the adulteration of food, drink, and drugs?

It will not be possible to discuss details connected with Public Health questions in a popular address, as there is not the time necessary to perform such a task. The collection of statistical evidence is of the first importance, and, fortunately for Great Britain and for the world, this is under the charge of men who are able, industrious, and competent workers. Registration of marriages, births, disease, and death, enables the student in sanitary science to compare the state of the public health, week by week, quarter by quarter, and year by year. But very much more information is required than any printed returns can show, before the simplest practical sanitary problem can be reasonably solved. The Registrar-General's returns are made up for "Registration Areas," which are not, in all cases, the best for the purpose; as some of these areas include towns, villages, and rural districts, living under conditions which produce results, favourable in some cases, and unfavourable in others. A small town has, for instance, been sewered, drained, and supplied with good water, cesspools and common privies may have been abolished, and such diseases as typhoid fever and diphtheria may have ceased; but in the registration area bearing the name of such town, unimproved detached residences and villages are included, and diseases incident to defective conditions prevail in these houses and villages, and are classed in the return as having

occurred in the town which has been improved; there may be also county hospitals, asylums, workhouses, and gaols, the deaths in which are registered as occurring in the town, though really due to the districts whence they came. This is a double injury; it injures the town, and also misleads the outside public. The subject has, however, previously been noticed, and will, probably soon be amended. The returns given for large towns are also imperfectly instructive. It is very desirable to know how one great centre of population compares with another, as London with Paris, Berlin with Vienna, Manchester with Leeds, Liverpool with Glasgow, and Edinburgh with Dublin; but the figures, 22·50 per 1000 for country districts, and 25·75 per 1000 for town districts—25 for London and 35 for Vienna, do not tell much of the sanitary story; as, in each area, there are divisions and subdivisions innumerable, and variations which, if fully stated, would simply be frightful. In that vast aggregation of humanity which we call London, and which we also complacently consider the healthiest city in the world, in place of reading, "25 per 1000" as the "average" return, we should learn from the details that there are districts in which the mortality ranges from 50 up to 100 (and more) per 1000—human dens of wretchedness, crime, and pauperism; the owners of property in such districts having no regard for sanitary improvement, but to avoid or to retard it.

The term "preventable" has been applied by sanitarians to deaths occurring from zymotic diseases, and deaths above the standard of 17 per 1000 are considered preventable. There are "preventable deaths" and "preventable cases of sickness" also, the latter being 30 or 35 times the greatest; that is, for one preventable death, there will have occurred 30 or more cases of preventable sickness of longer or shorter duration, and to this "preventable sickness" may very fairly be attributable half of the excessive poor's rate.

The conditions which affect public health are various, complicated, and difficult to understand. Climate, seasons, excesses of heat, of moisture, and of cold; modes of shelter, of clothing, of feeding, and of occupation; immigration and emigration; all influence the public health.

Statistical evidence being obtainable—its proper use is the difficulty. Various writers—ancient and modern (recently Dr. Guy)—have recorded the rise, course, and terrible effects of plague, pestilence, typhus fever, and cholera; and we have a tolerably full library of books detailing the past ravages of black-death, sweating-sickness, and other diseases, as also of typhus, diphtheria, small-pox, scarlatina, and cholera.

A series of reports preceded the passing of the "Public Health Act, 1848," elaborately detailing the sanitary conditions of the population of England, the Report of 1842 being at the head of this class of literature for completeness. This (1842) Report embodies the labours of many observers and workers, and may be said to have dissected modern society in England. Towns, we learned,

were not sewered; houses, we also learned, were not drained; or works of this character were so rude and imperfect as to be causes of nuisance rather than promoters of health, the first principles of sanitary engineering not having then been worked out; villages and single houses were also found to be in bad plights. The great "Report on the Sanitary Condition of the Labouring Population of Great Britain, with Appendices (1842)," and the "Supplementary Report on the Practice of Interment in Towns," by our colleague, Edwin Chadwick, Esq., Barrister-at-Law (1843), set forth, in an understandable form, the sanitary evils of our period, and in the Session of 1848 the Public Health Act became law. The Irish famine-fever of 1846-47, the outbreak of cholera in 1849-50, and in subsequent years, have given an impetus to remedial sanitary works which has steadily progressed. The Russian war of 1854, and subsequent years, but especially the severe mortality in the British army in the Crimea during the autumn, winter, and spring of 1854-55 (through the thoughtful and wise intervention of Lord Shaftesbury), induced the Government of the day to send a Sanitary Commission to work at the great hospitals on the Bosphorus, and at the camps in the field. A Commission was also sent out at the same time to inquire into commissariat defects. The records of the work done and of the results accomplished are embodied in the Reports. Since this period Army Sanitary Commissions have been generally established in the various armies throughout the world.

The great mortality in the Crimea during December, January, and February, 1854-55, which amounted in some regiments at the front to 70 per cent. of the men encamped, alarmed the Government. Climate, exposure, and trench-duty were cited as the causes; the men, however, it was found had no suitable clothing or rations; even commissioned officers wore their clothes until they swarmed with vermin; there was no fuel to make fires for cooking, and the rations served out consisted of raw coffee berries, hard biscuit, salt pork, and rum. The road from Balaclava to the front, in a limestone district, with thousands of tons of this rock washed from the mountain's sides ready and handy for use (during the first winter) was never touched, and the road became a quagmire. The small but commodious harbour of Balaclava was allowed to become, from one end to the other, a mass of floating animal and vegetable garbage, and the village and the camp were tainted with human and animal filth. The hospitals on the Bosphorus were frightfully overcrowded; they were also unventilated, and both within and without were as bad as dirt and neglect could make them. Miss Nightingale, in "Notes on matters affecting the Health, Efficiency, and Hospital Administration of the British Army, founded chiefly on the experience of the late War, presented by request to the Secretary of State for War, 1858," furnishes all the details. The world has heard that Miss Nightingale went out with her lady companions to nurse the sick and wounded, but it is not so widely known that this self-imposed duty, important as the results have been, only constitutes a fractional portion of the

labours of this lady. In my opinion, the labours of all other workers in the cause of army sanitary improvement sink into insignificance when compared with the work she has accomplished in this direction down to this time. The effect of this labour has been the appointment of Sanitary Commissions, which have inquired into the condition of barracks and hospitals in Great Britain, at the Mediterranean stations, in India, and, in fact, wherever a British soldier is stationed on duty throughout the world. The results, so far, are greatly reduced rates of mortality in the army, both at home and abroad.

Recent reports from India detail the local causes of excessive disease in that climate. These causes are: filthy native huts and filthy palaces; filthy villages, filthy towns and filthy cities; as also filthy British soldiers' barracks, filthy hospitals, filthy prisons, filthy cantonments, and even filthy sanitary hill-stations. The low class natives of the plains of India are described as being habitually dirty, idle, and apathetic. The native's water sources are frightful abominations, the water in rivers, tanks, and wells, being contaminated by human and animal excreta, and even by putrefying carcases of man and beast; drowning in tanks and wells being common, the bodies, in some cases, wasting as the water is drawn for use. On cleaning some of these tanks and wells deposits of human bones have been found and removed, which bones indicate the fact that all other portions of the carcases had been dissolved in the water. Contamination of tanks and wells by washing, bathing, and infiltration of excreta and decaying animal and vegetable refuse is common over the whole of India, so far as we know it.

The sanitary condition of populations is to be studied primarily in their dwellings. If men have no means of observing the decencies required by civilisation, it may reasonably be expected that the doctrines which inculcates purity of life, of thought, and of speech, will be a dead letter. This question of human habitations is, therefore, the greatest problem sanitarians and statesmen have to solve; sewering, draining, water-supply, and scavenging, being works of secondary importance.

So far as history illustrates or explains anything connected with the past condition of the masses of mankind, the story is one of utter State neglect in securing decent home-accommodation. In ancient times the masses were slaves or in some respects worse than slaves, as ownership imposed responsibility, but the free peasant has been for the most part utterly neglected, and left to house himself as he could. This has been true of the past, and is also true of the present. It is true of country districts, it is also true of towns and of cities, however magnificent they may be in their outward appearances. To describe the mud and bog cabins of Ireland, the bothy of Scotland, and the cottage of England, would be to depict nests of foul air, of scrofula, of physical debility, and of moral impurity. The sanitary defects which exist in the lower-class dwellings of Great Britain exist in the lower-class dwellings of every nation and people on the face of the earth.

There are reports in abundance on English, Scotch, and Irish villages and towns, setting forth the facts in all their hideous details. Single rooms occupied by all the members of a large family: father, mother, brothers, sisters, and male and female lodgers (sometimes pigs and dogs), mixed in one nest of impurity. Poverty is not always the cause; and, if it were so, should this continue to be a satisfactory excuse? Will sanitary reports, describing the wretched abodes of the teeming populations, or sanitary rules and recommendations, left to chance enforcement, avail in enabling the country peasant, or the town artisan, to follow the advice given? If the work of the State stops with reporting and recommending, may not its action be termed a delusion and a snare?

Poverty is recognised by the Poor Law, and property is made to bear the pecuniary burden of relieving it; sickness is recognised by private charity, hence the various forms of endowments, as also the building and support of public hospitals, making charity fashionable. Crime is provided for in the erection of gaols, the maintenance of legal tribunals; and punishment becomes the work and cost of the State. These arrangements are, at this moment, almost the full extent of the national measures of civilisation in England. Sanitary legislation, it is true, commenced in 1848, and Act upon Act has since been piled up, one to mend the other, until confusion is the result. Men "learned in the law" cannot even understand, and of course cannot interpret, these Acts.

A Royal Commission under the chairmanship of Sir Charles B. Adderley, M.P., has been taking evidence relative to sanitary laws, and is expected to make a report, with recommendations, in time for the Legislature, in 1871. Whether Parliament will provide any practical remedy for improving human dwellings generally remains to be seen. Poverty of the occupant is a plea which may be put forth by the peasant in the country, and also by the labourer in the town, and which cannot be gainsaid. The unaided poor cannot provide their places of residence, but must try to exist in such as they find; the poverty of the individual is, therefore, an effectual bar to improvement by him—he must take his tenement, his health, and his morals, as provided and arranged for him by others, and, if born with an unsound constitution, the result of defective sanitary legislation, Poor Law taxation will have to keep him; and if example inculcates crime, he will oscillate in and out of gaol. The worst of the males learn crime and live by it. The most tempted of the female portion of such families may drift into prostitution. The wealth of the State is not saved by this malarrangement; a fact which has been explained and proved over and over again.

Defective house-accommodation produces disease, immorality, pauperism, and crime, and has done so from generation to generation, until vice has become a second nature, and morality, virtue, truth, and honesty, to human beings so debased, mere names. The money expended in relieving pauperism, in detecting and in punishing crime, and in supporting the sick, if properly expended,

would provide funds sufficient to furnish improved house-accommodation. Taking floor-areas and space into account, and the money expended within such spaces, it will be found that wretched dens of misery and vice are more costly to the community than any equal area and cubic space in a palace. There are tenements by hundreds of thousands, which tend to generate sickness, pauperism, and crime, the cost of which is paid for out of rates; and yet such tenement or cottage-property is not worth more than from three to five years' purchase; but the round of degradation is allowed to go on. Zymotic diseases cut down the head of a family; typhus removes a father in the prime of life; and the family is then left to the care of the parish. "Once a pauper, always a pauper," has become a proverb. Statesmen have, therefore, this lesson to learn—namely, that that which is necessary to the well-being of society, and which individuals cannot provide, but which the State can provide, must be the bounden duty of the State to furnish.

It does not follow, as an inference from these arguments, that the State must build and own cottage-tenements, but it may be inferred that it ought to frame laws, and provide means and machinery for enforcing such laws and regulations as are necessary to bring about the required improvements.* State aid has been and is afforded in many forms, but upon no defined or settled principles applicable to the requirements of the empire. There are Exchequer Loan Commissioners, who, however, are only State hybrids—they are not a Government department, neither are they independent, but being in connection with the Chancellor of the Exchequer, they can advance State money on loan for various purposes. Parliament also by fits and starts votes money for public purposes outside strict Government requirements—as to relieve the Irish Famine, 1846-47; to drain agricultural land; to promote special occupations, such as fisheries; to construct roads, canals, harbours, and river improvements; and to provide for the execution of sanitary works, as in Lancashire during the cotton famine. Corporations and local boards can also borrow money from Government for main-sewering, for water-works and for general improvements; but not on any simple, easy, and equitable principle, as the rates of interest charged vary from 3 per cent. to 5 per cent.; Exchequer loans are also as a rule discouraged.

The question may be asked—Should the State halt on the threshold of so wise an arrangement as lending money to aid sani-

* Since the above was written, the Consolidated Sanitary Acts have become the Public Health Act of 1875; there is also the Working Men's Dwellings Act, 1874, and the Artizans' Dwellings Acts of 1868 and 1875.

Those who remember the Model Cottages of the late Prince Consort at the Great Exhibition in Hyde Park (1851), may be told that His Royal Highness, at that time, had studied the question, and had fully recognised the great importance of proper cottage-accommodation both for country and for towns. The example then set has been followed in parts of Europe and also in parts of Great Britain.

tary improvements? The money (£1,750,000) lent to the distressed cotton districts (1863-69), under the supervision of the Right Honourable C. P. Villiers, M.P., then President of the Poor Law Board, has been expended on works of a permanent and sanitary character, such as main-sewers, house-drains, forming streets and roads, constructing water-works, and other works of local improvement; thereby securing to the inhabitants means to enjoy health, comfort, and greater facilities for locomotion and trade. The advance of this money relieved local distress, at no cost to the State,* because the local rates are mortgaged as security, and both the principal and interest (at 3½ per cent.) will be repaid to the uttermost farthing, within a period not exceeding thirty years. If Government would lend money, at this rate of interest, to enable Parish Authorities, Town Councils, Local Boards, Improvement Commissioners, and other similar public bodies, to improve dwelling-houses, to sewer, drain, construct water-works, markets, &c., and to effect street, road, and other town improvements, the progress of the whole country in sanitary improvements would be rapid, and the Registrar-General would soon be enabled to record the beneficial results in his returns; pauperism would cease its alarming growth, and crime would be lessened.

The State, under outside pressure, has recently done something in the way of facilitating the improvement of workmen's dwellings—as, by passing an Act (29 & 30 Vic. 28) to enable the Exchequer Loan Commissioners to advance money on loan (at 3½ per cent.) to assist limited liability companies formed for the erection of Dwellings for the Labouring Classes—such loans to be in aid or extension of capital subscribed and paid up. Sir Sydney Waterlow's Company, in London, has obtained money so provided, for the purpose of erecting improved dwellings, as contemplated. Mr. McCullagh Torrens, M.P. for Finsbury, has also obtained an Act (31 & 32 Vic. 130) to enable local authorities, on the certificate of a sanitary officer, to compel, summarily, the improvement or removal of house and other property certified to be unfit for human habitation. There are several independent associations of benevolent men in London, in Leeds, in Hastings, and in other towns, who undertake the purchasing of house-property notoriously bad, as Wild's Court, London, for the purpose of improving the same; and great moral and sanitary improvements have thus been and are being accomplished. Lord Shaftesbury, by the Common Lodging-houses Registration and Inspection Act, has effected much good. The benefits conferred by this Act are so much appreciated that tramps assist to enforce the rules as to cubic space, clean bedding and ventilation. In Liverpool the Corporation has obtained power to purchase overcrowded cottage property, and to remove so much of the same as may be considered necessary to secure an improved state of public health. This work is going on. Sunderland has obtained similar Parliamentary

* The administration of this sum of £1,750,000 has not cost Government more than 3*s*. 6*d*. per cent. in clerks and office expenses.

powers, and is proceeding, or is about to proceed, to pull down the most defective house property in that borough. The late Mr. Peabody's large bequest of £500,000 for the improvement and erection of industrial dwellings, by a judicious investment of the growing net revenue of the fund ought, in the next fifty years, to go far towards providing industrial dwellings, of the best character, for artizans and others requiring house-accommodation in London. There are in all parts of the kingdom charity funds, to a very large amount, left by former benefactors for many purposes which have become obsolete, or even mischievous, which funds the Charity Commission might be empowered to reappropriate to more useful purposes, especially in the direction of providing improved cottage dwellings.

We now want a report or treatise, of an exact and statistical character, setting forth with clearness and precision the financial, sanitary, and moral results of the more important industrial dwelling undertakings in this country of the last fifteen years. Financial, in order to bring to a practical test of profit and loss, expenditure undertaken in different parts of the country under ordinary or peculiar conditions. Sanitary, in order to show that improved house-accommodation means less sickness, less mortality, healthier children, and higher wage-earning power. Moral, in order to show that better dwellings mean sober habits, accumulated savings, and an almost total absence of offences against the law.

The first steps in sanitary progress are, as previously indicated, special examinations and faithful reports; and then remedial measures ought to follow. The inspections and reports in England have, to some extent, been followed by works, and at the present time the Local Government Act (1858) has been adopted in some 700 places, and the number is being added to. A sum of about £8,000,000 sterling (exclusive of the metropolis) has been expended on the various works provided for by the powers of the Act, such as sewering, draining, water-supply, road and street improvements, &c.* To put the whole of England in a similar sanitary state will cost about £50,000,000 in addition. In round numbers, from £2 to £5 sterling per head of the population under the Act may have been expended. Large as these figures appear, when thus stated, the expenditure has been, and will be, a relief and not a burden. House-property has been, and will be, increased in value; and, in so far as causes producing zymotic diseases are removed, the ratepayers will enjoy better health, earn fuller wages, and will be, consequently, better enabled to pay the rents demanded. There are many persons, however, who do not appear to value health, if providing the means to obtain it touch their pockets.

* This £8,000,000 represents the Public Debt; but as private improvements are paid for by owners and occupiers, and, as a rule, the private expenses of drains, closets, cisterns, pipes, and apparatus, cost about as much as the public works, the expenditure on sanitary works and apparatus has not been less than £16,000,000.

These persons, in towns and villages, are small shopkeepers, in business or retired, small speculative builders, and owners of cottage-property, generally owners of cottages of the worst class, which, on account of their badness, are relieved from paying rates, but in which fever and pauperism are manufactured with singular regularity, the parish relieving-officer indirectly, but nevertheless regularly, paying the rents.

Since the Crimean War, and the effective work of the first Army Sanitary Commission, there have been commissions, inquiries, and reports, as to barracks and hospitals on home stations, and works of sewerage, drainage, water-supply, and of ventilation have been carried out, the results being a great reduction in the sick rate, and a reduced annual army death rate of about 8 in each 1,000. The Mediterranean stations have been examined; the water-supply of Malta has been improved, plans and estimates for main-sewering and draining are ready, waiting to be adopted and carried out; Gibraltar has been sewered, drained, and furnished with an improved supply of water; and India is now the seat of a vast sanitary movement, and many reports upon towns and stations have been ordered and sent in. To extract only fragmental portions of these reports would occupy more space to write and time to read than are allowable in an address. Calcutta, the capital of British India, is thus described:—

"It is beyond contradiction that the present condition of Calcutta is highly unsatisfactory, and is a reasonable cause of alarm to the sanitarian. I write advisedly when I assert that, for flagrant nuisances, stagnation of filth, vast accumulations of excremental matter, vegetable and animal decay and putridity, foul effluvia from open drains, sickening odours generally, sewage contamination of air, water, and soil, impurity of drinking-water, horrible defilements of every sort, inefficient scavenging, want of proper drainage, and general sanitary maladministration, Calcutta will compete with any other city at home or abroad."*

India is described in the Sanitary Reports recently sent to England as one vast field of general uncleanliness, and consequently the ravages of disease and death are excessive. The delta of the Ganges, in all its seats of human habitation, is a vast area of filth of every type to be found where sanitary regulations have been, from the remotest periods, utterly neglected. The sacred river, in the monsoon periods, brings down the tropical rains and inundates large areas, drowning out disease for the time. The waters subside, the fierce sun dries up the swamps, putrescence begins, and cholera again reigns, ripening the germs to be matured as seasons favour the process. Cholera need not be any longer considered a mystery, as the disease obeys well-ascertained laws. Its birth is in the midst of indescribable human filth, which is removable; its spread is along lines of human communication where filth abounds, irrespective of all other terrestrial or meteorological considerations; there must, however, be human populations to generate cholera. The course of rivers, stratifications, and even elevation, have appa-

* David B. Smith, M.D., Sanitary Commissioner for Bengal.

rently little influence; but, given a population grovelling amidst filth, and there may be cholera—from the tropics to the poles.* New countries were said to be free from old world diseases; but, alas! this has been only for a time. Zymotic diseases, at first unknown, are now rife in the Australian towns, since population has increased; like causes producing like results.

The sanitary condition of a State is visible to the eye of a stranger and student, in the bodies, features and rags of its population. The dirty, half-naked, stunted, squalid, diseased, blind, and crippled mendicants, of any country, as well as the ragged, able-bodied, and bold beggars, declare the result of defective legislative provisions and sanitary regulations. The street-arabs and tramps of London, the English paupers, the ragged and turbulent peasants of Ireland, the barefooted women and children of Scotland, all show that vast masses of the population of Great Britain and Ireland are uncared for. Degeneracy is most painfully visible; the human face and form present hideous squalor and distortion—and as is the body so is the mind. Such scrofulous populations are an incumbrance, a money loss, and a civil terror.

Sanitary works may be simple in country districts, but in towns they become compound, and, therefore, complex. Municipal, parochial, and personal care and labour are, however, required under all conditions—a fact which has not, as yet, been generally appreciated and acted upon; hence arises, from personal, municipal, and parochial neglect, much of the nuisance wrongly imputed to sanitary appliances.

The physician and the sanitary engineer must also, as a first lesson, learn the simple laws of nature, that they may know their weakness, as also in what may consist their power; as the grand phenomena of nature cannot be controlled.

The atmosphere is the breath of life, but a contaminated atmosphere produces sickness and death. Temperature, dryness, and moisture, affect health; and it will be wisdom to understand how far these conditions are beyond the control of man, as also to what extent he may modify them.

The sun is the source of heat, and this heat is dispersed through space, year by year and age by age. It is suspected that some annual variation can be observed in the volume and effects of the heat of the sun in the earth's atmosphere.† The salt ocean is the source of vapour, and the annual volume of aqueous vapour raised

* Cholera has been said to prevail, in excess, on certain geological strata, and to avoid regions of granite—to follow the course of rivers—to be most deadly on low sites. Where populations are massed for purposes of commerce, and live in neglect of sanitary laws, there cholera may prevail, in excess, on any strata or on any site.

† In meteorology, seasons vary, in the fall of rain, about as 1 to 2: that is, if a dry season gives 20 inches of rain in the year, a wet season will give 40 inches; and an average of years will give 30 inches. Does the heat of the sun vary so as to produce this meteorological variation in the evaporation and in the fall of rain?

into the atmosphere will necessarily be in proportion to the heating power of the rays from the sun, and as the moisture will be in proportion to the heat and water evaporated, so also will be the precipitation of moisture in the form of snow, hail, dew, and rain. Temperature and moisture affect the public health seriously in several ways: vegetation is affected; through vegetation animal life; through animal life man. A series of exceptionally dry seasons produce famine; a series of wet seasons produce blight in vegetation, murrain in cattle, and then wide-spread epidemics in man. History furnishes the details, though historians do not in all cases recognise their importance. Science is young, but vast advances have been made in the study of meteorology, and the aids now afforded will enable students to discard ancient fallacies and establish new truths; local tables of weather predictions, in detail, will become obsolete; forecasts, for continents and islands, will become common. The electric telegraph will be the warner and teacher of the meteorologist, as by its aid he will have note of the tornado at its birth, and by experience indicate its probable course; then, to be forewarned will be to be forearmed. Commerce, under free trade, can save from famine; and sanitary science can mitigate the severity of vegetable epidemics; man cannot, however, regulate cosmical changes, nor will any work of man more than fractionally modify cosmical effects; continents and islands, parts of continents and parts of islands, will continue to have seasons of scorching drought or of deluging rain, irrespective of the destruction or growth of forests, the drainage of land or its cultivation.* A few facts will illustrate this. In the year 1864 the continent of Europe suffered drought; Australia was flooded by successive falls of rain. In 1866 Australia experienced a fatal drought; Europe suffered from excess of rain. This year (1870) great drought again prevails in portions of the northern hemisphere, and Australia is again deluged with rain; that is, there is more than the average of drought and of rain alternating. There are not, however, entire seasons over the surface of the world, either of drought or of rain; there is only equality in an average. At what point heat and moisture are friends or foes, the physician must study; a few degrees more of heat in summer, or of cold in winter, affect the Registrar-General's returns, both of sickness and of death.

Meteorology also affects water-supply. The heat of the sun causes evaporation from the ocean, and the vapour is condensed into pure water (soft water). There is no other source of pure, soft, and fresh water but the salt ocean. All fresh water found in springs, rivulets, streams, rivers, and lakes, or in the substrata of the earth's crust, has therefore been evaporated from the salt

* Forests affect meteorology only over their own local areas, to the extent of several degrees of temperature. Land-draining and cultivation also affect local temperature only, and that during ordinary periods, but these neither lessen nor increase the excesses of nature in her storms or in her calms.

ocean, and after permeating the subsoil, or flowing over the surface, wends back to the great ocean-reservoir of the world, again to be salted, purified, and re-evaporated, and floated once more in the air to the virgin springs and streams.

Public water-supply has been greatly extended within the last quarter of a century, both at home and abroad. The metropolis obtains its 120,000,000 gallons per day, partly from the river Thames, and partly from the river Lea, which, however, is a tributary of the Thames. Both these sources are polluted by washings from manured lands, from roads, and also from villages and towns, such washings containing human excreta. Boating and bathing are common to both rivers. Liverpool, Manchester, Bradford, and many other lesser towns, have obtained soft and comparatively pure water, and works are in progress for Leeds, Huddersfield, and some other places. Glasgow has Loch Katrine water in abundance, Dublin that from the Vartry, both sources producing water soft and pure. A few instances may be named of waterworks in different parts of the world; as in America, New York has the Croton and Brooklyn waters, and Chicago takes water by a tunnel driven under the shore-bed of Lake Michigan. In India, Calcutta is completing a scheme for taking water from the river Hoogly; Bombay has the Vehar reservoir; and in China, Hong-Kong is having an impounding reservoir constructed at Poke-Foolum to supply that station with water from the surface of the granite.

Sanitary science, before it can be of practical use, must be learned by statesmen. The strength of a nation is in its health, and where there is the healthiest community, there bodily purity and morality will have the greatest development. Empires, Monarchies, and Republics have this lesson to learn. In the cities of the Republican States of North America, the worst sanitary defects of the worst cities in Europe are being repeated.

The aim and end of statesmanship ought to be to ensure to every individual born into the State means of health and of morality. Each Englishman's home should not only be his castle, but his hospital. Charity will not then degrade but will elevate; and that alone will be true charity which assists the poor to assist themselves, and so to live, independent of alms-begging and alms-giving.

The sanitary engineer and manufacturer of the future will know nothing of waste products, because sewage will be used as manure; and the ingredients which now pollute and destroy our rivers will be converted to profitable uses. Smoke may be prevented, and noxious fumes may be condensed.

The statesman of the future will make social questions his study and care; and, whilst providing for defence and taxation, he will see that measures necessary to the prevention of disease and mortality in excess shall also be provided and administered; and if all the foul dwellings in country and town are removed, and wholesome tenements substituted, and all the waste products of manufactures and populations are utilised, which now tend to destroy

human life by polluting the streams and rivers, and make healthy life impossible in the country, the money saved and made will go far towards providing a sufficient fund out of which to repay the national debt.

We are now proud of our charities, proud of our public hospitals, which cost £1000 per bed, plus the additional expenses of administration, in which hospital-beds sick men are treated at a money rate three times greater than the wages they could ever earn when in health. "Our charitable institutions are the glory of our land," but happy will that State be which neither possesses nor needs such extravagantly costly forms of glory.

We repeat at our great musical festival the angelic chant:—"Peace on earth, good will to men," but we read in our daily papers of carnage such as the world never before knew; we cannot explain the terrible phenomena, but stand aghast in dread and wonder. The war epidemic is upon the nations, and will run its course. Sanitary science, under such conditions as are now in existence, appears to have laboured in vain. But it is our duty to work in hope and wait. War and carnage are not the end of Christian teaching; we must strive to look beyond the present, and hope for better times. The poet, using his divine faculty, states—

> "For I dipt into the future, far as human eye can see,
> Saw the vision of the world, and all the wonder that would be."

And in another verse embodies the hopes of men, who do not despair, in words with which I conclude this address—

> "Yet I doubt not thro' the ages one increasing purpose runs,
> And the thoughts of men are widened with the process of the suns."

DOMESTIC SANITARY ARRANGEMENTS.

A Paper read before the National Health Society, 7th November, 1872.

I BEG to be allowed to preface this subject by a few general observations, because domestic sanitary works cannot be accomplished if unaided by the State.

There can be no such thing as entire independence in a civilised country. Where there are several houses near each other, or villages, or towns, there must be mutual action for the good of the whole. The question of absolute ownership will not be discussed here further than to remark that law is the first step in ownership, as without law in some form men would no more own the soil than do the brute beasts which graze the herbage; law creates ownership, and may therefore control it. This brings us to the right of a State to enact sanitary laws; and here we are on the threshold of a most complicated and much vexed question. What shall these laws be, and how shall they be enforced? Those who have read history will know that oppressive laws are self-destructive.

Combination is here permissible and necessary. We must, however, see to having the unit good that the combination may be good also. Modern society in Great Britain is strangely constituted: with vast wealth there is great and wide-spread poverty; with the highest state of learning there is a wilderness of gross ignorance; with many bright examples of religion and purity there is a terrible strength of vice and practical infidelity, and much of this vice is, to our shame, voluntary; the individuals indulging in it having birth, rank, wealth, and social position. Our hospitals show forth, if not in all cases our wisdom, our so-termed charity; and, at the least, our prisons are healthy, though many of our cottages are dens of misery. We have advanced so far on the road of national improvement as to have made excess of disease in a prison impossible; but have left health and virtue in a labourer's cottage almost impracticable. If it is the duty of a State to punish crime and preserve criminals in health, will it ever be the recognised and practised duty of a State to foster virtue, and so to legislate as to preserve the honest man in health? And, as the State allows the claim of existence under the Poor Law to be national, may we expect that it will in time perceive the truth that prevention of extreme destitution will be better, because safer, than

punishment or parish relief? Unfortunately, at present, country and towns are involved in poverty and misery, the offspring of sanitary neglect; the smallest village fosters vagrancy; and towns aggregate vice—our cathedral and university cities ranking among the worst. Charity does not now, in many cases, retain any part of its original meaning; as it may be said of some endowed localities, that in proportion to the number and wealth of the endowments and charities, is the corruption of the unfortunate inhabitants.* Again, to give alms to importunate beggars is to feed vice and crime.

I hope you will bear with me in making a few general remarks which some may consider self-evident. It is well, however, sometimes to restate truths the most simple. We have, for the most part of our lives to do with individuals, and most with ourselves as the unit, and if we cannot manage ourselves we shall only be poor and imperfect teachers of others.

The universe is made up of atoms. Nations are made up of individuals, each in some degree affecting the whole body, because as are the individuals so will the nation be. The fountain and prime element of all value in this world is human life—healthy human life having the greatest value. In an individual, disease of any limb or organ affects the whole man. In nations, ignorance, vice, and suffering cannot be confided to individual sufferers.

Great wealth and squalid poverty are antagonistic, the latter tending to destroy the former. A wise Government will, therefore, take special notice of the poor and of their houses, so that populations in cities, counties, provinces, and kingdoms, which compose empires, may be healthy, moral, and safe.

As are single houses, so must their aggregation be. Filthy houses breed squalid people; neglected filth fosters squalor, poverty, immorality, disease, and crime. Ignorance makes superstition possible; superstition makes true religion impossible; and where superstition and irreligion prevail, truthfulness is absent. An individual without truth is an unsafe citizen. A nation without truth is in a state of disintegration. A strong nation consists of healthy, religious, honest, and truthful citizens.

It must consequently be the prime duty of a Government, by wise laws and regulations, to insist upon the construction of healthy houses for the people. Healthy human life being the only source of wealth and strength, the expenditure requisite to secure this health and strength cannot be greater than the necessity requires.

To effect human amelioration, statesmen must consequently learn the alphabet and grammar of the laws of human life, and legislate accordingly. At present medical men attempt to cure diseases, magistrates commit for crimes, and judges condemn. Local authorities bear the cost, leaving the seed-bed of this horrid crop untouched.

* This has reference to some municipal and guild endowments and to some private charities, and is not intended to include universities, public schools, and other endowments which are well managed.

Loyal citizenship, wholesome life, and morality, have their roots in clean and wholesome dwellings.

My remarks in this paper on defects and remedies will not be so practical, continuous, and terse as is desirable. The subject would require much fuller writing, ordering, and re-writing, and would then become a tolerably big book. I wish now merely to give you random hints to think over.

Private sanitary works must be adapted to site, construction, and architectural arrangements. It will be impossible to describe all existing mal-arrangements. I really dare not tell all I know to this meeting. Some few facts out of many which I have ascertained I may, however, name.

I have examined noblemen's houses where the entire basement has been saturated with sewage from the discharge of many water-closets.

In the year 1844 it was found that within the basement of Windsor Castle there existed fifty-three cesspools full and overflowing. No window in the Royal apartments could then be opened at the top, the warming and ventilating arrangements being of the poorest description. At present Windsor Castle is, however, in a more perfect sanitary state than any other palace in Europe.

Some mansions defectively sewered swarm with rats bred in the large foul drains; these vermin are a certain indication of foul sewers.

The hotels in Edinburgh, Glasgow, and other cities, have water-closets, for the most part, betwixt bed-rooms, or on inside corridors, and without any means of proper ventilation.

Old houses of the larger sort, both in country and in town, usually have large internal sewers, cesspools, and foul subsoils; hence much sickness and many premature deaths.

Ventilation of houses on any system has seldom been thought of. Staircase windows are fixtures; bed-rooms shut up tight; and, if there should be any cracks or escapes to let in air, these are papered or "listed" up, sand-bags being laid along the divisional sash-bars of the windows.

If there are flues and fire-places in rooms, these, in summer, and frequently in winter also, have the register closed, or are boarded up, or papered, or both. Fresh air—the breath of life—is treated as if it were the greatest enemy.

The social and moral abominations resulting from over-crowding in room-tenements, may be found described in sanitary and police reports; the sexes, adults and children, having often no means of separation. A midnight inspection of such dwellings is an awful spectacle.

The following are rules that should be attended to:—

The subsoil beneath a house should be naturally dry, or it should be made dry by land-draining.

The ground floor of a house should not be below the level of the land, street, or road outside.

A site excavated on the side of a hill, or steep bank, is liable to be

dangerous, as external ventilation may be defective, and the subsoil water from above may soak toward and beneath such houses. Middens, ashpits, and cesspools, if at the back, must, also, taint such basements.

The subsoil within every basement should have a layer of concrete over it, and there should be full ventilation.

Cesspools, cesspits, sink-holes, or drains, should not be formed nor be retained within house-basements.

The ground around dwelling-houses should be paved, flagged, asphalted, covered with concrete, or be gravelled.

Outside channels should be in good order, and be regularly cleansed.

House-eaves should be guttered and spouted.

Swill-tubs should not be near doors or windows.

Pigsties should ever be at a distance; and, where pigs are kept, there should be rigid cleanliness. Improperly keeping pigs has caused more human sickness and destroyed more life than all the battles the country has ever been engaged in.

Garden plots should of course be in order and be properly cultivated.

Many houses, from the mansion to the cottage, are unwholesome for some of the following reasons:—

1. Damp and unventilated basements.
2. Cesspools and foul drains within the basement.
3. Rotten timber in floors and skirtings and tainted wall papers.
4. Kitchen sinks in improper places and unventilated.
5. Water-closets in improper places and unventilated.
6. Rooms without adequate means for ventilation.
7. Water-cisterns and pumps in improper places, supplying contaminated water.

These defects should be remedied by landlords. Houses are also unwholesome from accumulated dirt, carelessness, and personal neglect. As when—

1. Rooms are not sufficiently cleaned.
2. Carpets are left down too long and never swept.
3. Windows are seldom opened.
4. Water-closets are dirty, neglected, and without ventilation.
5. Dirty beds are unmade, and shrouded by dirty hangings.
6. Dirty wardrobes, and dirty clothes closets.
7. Nooks, corners, and shelves which are never dusted.

I cannot be expected to teach ladies how to attend to these things, neither does it require a Sanitary Commissioner gravely to take up his parable and say, "attention to cleanliness generally is necessary."

A lady, Mrs. Elizabeth Hamilton, in the beginning of this century wrote a charming story, "The Cottages of Glenburnie," describing Scotch cottages and cottagers' lives in the last century, which description, true then, is also true now, not only of Scotch cottages, but also of English, Welsh, and Irish cottages generally,

so far as I know them. To our remonstrances and pleadings for alterations, repairs, care and cleansings, we get similar answers to those given to the good and wise Mrs. Mason of the story, "It does just weel enough," or "We canna be fashed."*

Sanitary education is required; as, having been brought up at school, or under private tutors, and finished at college, has not necessarily given the individual a true sanitary education. Order may not have been inculcated; thoroughness may not have been insisted upon; absolute cleanliness in after-life may therefore be found wanting.

The word "comfort" is not applicable to slovenliness and dirt; although, so long as health endures, some mucky people seem to enjoy themselves, like pigs in a puddle. But those who have visited and inspected dirty neighbourhoods, dirty houses, and dirty people, know that sickness and squalor banish comfort. Assistance and sanitary teaching are therefore required. That is not true charity which takes cake and wine to fever-cases in over-crowded dirty cottages, and leaves the over-crowding, dirt, and squalor unremedied.

There are points of construction to be attended to which I will name, so as to put them on record for the remembrance of those who may, at some time or other, build cottages or small houses, or be in communication with those who do build, or are going to do so.

Do not build on heaps of rubbish, fillings-in with cesspool refuse, chemical waste, or on swampy ground which cannot be drained. Thousands of houses have been so placed, and are now being so placed, in the suburbs of our towns.

A bed of concrete over the site of cottages will vastly modify otherwise objectionable positions; but, indeed, a bed of concrete should be used in all cases.

Houses crowded together and slightly-constructed cause great subsequent misery. There are people who will run up houses in the worst possible way, if allowed to do so, to obtain a larger rent or dividend.

At the beginning of this century there was no Act for the regulation of buildings in Liverpool; the town increased rapidly; low-class speculators piled up wretched houses in narrow courts where health was impossible; the local death-rate became the heaviest in England. But of late the Corporation obtained an Act to enable these courts to be partially pulled down, which has been done at the cost of several hundreds of thousands of pounds.

Back-to-back Cottages.—Cottages in courts entered by a covered passage; divisional walls half a brick thick; joists and rafters of three-quarter-inch boards, which a cat walking over will shake; stairs so steep and narrow as to be difficult and dangerous; chamber windows which will not open; cellars underground, in a hole, without drainage, and which cannot be drained; conveniences

* Miss Wordsworth's Journal is also a long record of dirty cottages and dirty people at the beginning of the century.

crowded against cottage walls; chambers over stable-middens, ash-pits, and privies, must be unwholesome and disease-producing;—the relieving-officer and the parish-surgeon know that they are so.

Sewering and draining in England have been vastly improved of late years, but are still far from perfect. Bad materials are used. But the worst faults arise through bad workmanship—I was going to say "defective workmanship." Well, it is defective—but the word "bad" implies that there has been carelessness on the part of the workman. London, after the millions expended, is defectively house-drained. Most houses in London are drained from the back to the sewer in the street at the front, so that basements are traversed by drains, many of them square on cross section, and leaky at the joints, so that the subsoil is saturated by sewage and is putrid. Then there are cess-pits which serve no good purpose, but retain sediment to corrupt and ferment. All such foul drains or cess-pits should be removed, as also the sewage-tainted subsoil, and new water-tight drains be laid in concrete; and these should be fully ventilated, externally.*

There has been one remarkable blunder in draining many West-end London houses—namely, making no connection with the street sewer. The sewers have been made by the parish, the house drains by the builders, and it has been no one's duty to see and certify to a correct junction, or, indeed, junction of any sort; so that when such houses are inhabited, subsoil flooding goes on, until both subsoil and basement are alike saturated. This has been pointed out over and over again, but no remedy is as yet applied. There are also, in some districts, old sewers not sufficiently deep to drain the new houses; one case has been made public (Park Lane—the Duke of Cambridge's house), but there are other cases of a similar kind in the metropolis.

House-drain ventilation is almost altogether neglected, the house-drain forming a continuous flue from the sewer to the house. Many cases of suffering to the weakly, delicate, and susceptible, spring from this sewage-gas poison. It is very easy to prevent this danger by simply breaking the top off the drain at a point outside the house, and ventilating it by a shaft and pipe.

Water-closets in a house are now a necessity, but many are most improperly placed; and are not in any degree ventilated. Such closets must cause discomforts at all times, and may cause disease and premature death. Ventilation to the open air is the only remedy. Closets within the body of the house should be dispensed with, and others be substituted on landings and against outside walls, so as to have direct daylight and open-air ventilation at the ceiling, which cannot be closed winter or summer.†

* House-drains can easily be ventilated: in London by a shaft, or by a pipe (of 4 inches internal diameter) from the drain carried above the roof; in the country, by continuing the drain to some higher point or to a garden-wall, and leaving the end open. Ventilate, or abolish, all cesspools.

† In many old houses a water-closet may be constructed outside the walls, in some cases being supported upon brackets projecting from the wall.

When society has advanced to the point of decency, this convenience will be really private. Most of the abuse, misuse, and filth connected with such places arises from common use. Our houses will some day be arranged to secure separation and privacy, which will ensure respect, and a lecturer will not need to comment on the subject. If continental nations do not follow the example, we must suffer, when abroad, or stay at home.

House-Ventilation.—What must I say about house-ventilation? All that I can say is that it is almost utterly neglected, from the palace to the cottage. Palaces, mansions, schools, houses and cottages, have walls, floors, ceilings, roofs, doors and windows, with chimney-flues, but no special and available means for ventilation.

The architect and the builder have striven, by perfection of workmanship, in first-class London houses, to have every room air-tight. What are the results? headaches on ordinary occasions, something indescribable when the rooms are crowded, as those learn who go through the horrors of a London season. If the atmosphere, and the consequences of breathing such an atmosphere, at a state ball, an evening at home, a private ball, or a large dinner party, could be made visible to the visitors and partakers, they would rush from such crowding with horror. We will not use each other's dirty plates, or knives, forks or spoons, but we will and do breathe the re-breathed and corrupted air of a crowded room.

To ventilate stairs and passages, open the staircase or passage window, or both, by drawing down the top sash several inches in summer, one or more inches in winter, and in some cases screw the sash fast, so that these windows must be open all the year round; if there is a skylight above the staircase, let there be ventilation here which cannot be closed. The result will be improved health to the family. Pay no attention to any casual remarks, "How cold your staircase is!" Let the ladies put on an extra shawl. But the remark will seldom be made.

Schools, as a rule, are very defectively ventilated; ordinary flat-ceilinged rooms are totally unfitted for Public Schools. The space should be open up to the roof-ridge, and this should be louvred.

Nurseries and children's rooms should be permanently ventilated. Dormitories for children require to have ample ventilation: clothe the children warmly, cover the beds warmly, prevent direct draughts, and the cool air will not injure.*

Avoid flue-ventilation of every sort; let the fresh-air come in as direct as possible. Night-air is the only air you can have at night, so do not fear it. Dread foul, because tainted, air manu-

* Bed-rooms may be permanently ventilated by the insertion of a panel which will open, or of a box in the wall close underneath the ceiling, having the outside and inside faces covered with plates of perforated zinc. The opening in the wall should be equal to 36 square inches, that is, 12 by 3 inches.

Permanent ventilation by windows may be obtained by raising the bottom sash a few inches, closing the open space, the outside air coming through betwixt the central sash-frames. The current will be a thin current of air upwards.

factured within the rooms. Any outside fresh-air is better than lung and skin-tainted inside-air.

In contrast to hospital and school ventilation, I have often looked at greenhouses as constructed and managed by horticulturists who rear plants, and have envied the plants. In greenhouses and conservatories generally there are means for warming and ventilation fully provided, the means being ingenious and simple; louvres in the roof can be opened or closed at pleasure the entire length of the ridge, so that the whole body of air can be regularly and evenly changed. The floor is elevated and dry, and fresh air can be admitted as may be required. Schools and hospitals are frequently the contrary of this. There are no means for ventilation in the roof, and if the windows are open a draught is created, chill is complained of, and so the windows and doors are kept closed. The children are dull and inattentive, the master or mistress, deadened by use to the sensation of the confined atmosphere, becomes delicate, and many premature deaths amongst school teachers are the consequence.

A horticulturist cannot afford to kill his plants; he lives by rearing and preserving them in health, and to this end warms and ventilates with the greatest amount of care. Shall we ever learn to provide for human beings, and treat them with a similar amount of skill, forethought, and care? This question deserves a practical answer, and I recommend it to the special consideration of the ladies and others who may be school-visitors.

Medical men have told me, that in their practice, when called upon to attend fever-cases in cottages, they have been obliged purposely to break some of the windows. In other cases, the medical man looks at the room and its surroundings, and if he finds it under the influence of some indescribable privy, midden, or cesspool nuisance, as is frequently the case, he orders the removal of the patient, as recovery is next to an impossibility under the existing conditions. Clergymen, medical men, lady visitors, parish officers, and policemen, know the wretched dens I have indicated.*

A pure water-supply is a prime necessity to health, but how rarely is pure water obtainable. In the country, if there is a pump, it is no unusual thing to see a dung-heap close to it; if there is a well, the top may be level with the ground, or it may be on the side of the road, or in a farm-yard, or on an open bit of common, where fouling must and does take place. I have cases in my mind of these several mal-arrangements, some in the most charming rural landscapes in England. The lady of the district may do much good by bringing about improvements; the dung-heaps should be removed, and the tops of the unprotected wells be raised and covered.

* At Leeds there are upwards of one thousand inhabited rooms which have middens, privies, and cess-pits beneath them. Throughout the manufacturing districts of Yorkshire and Lancashire there are such mal-arrangements by tens of thousands, which accounts for much preventible sickness.

In the 5th chapter of the 2nd Book of Kings there is a simple and affecting, but also instructive, story:—"Naaman, captain of the host of Syria, was a mighty man in valour, but he was a leper." A little captive maid of Israel, who waited on Naaman's wife, said unto her mistress: "Would God my lord were with the Prophet that is in Samaria! for he would recover him of his leprosy." We are then told that "Naaman came with his horses and with his chariot, and stood at the door of the house of Elisha. And Elisha sent a messenger unto him, saying, 'Go and wash in Jordan seven times, and thy flesh shall come again to thee, and thou shalt be clean.' But Naaman was wroth, and went away, and said, 'Behold, I thought, He will surely come out to me, and stand, and call on the name of the Lord his God, and strike his hand over the place, and recover the leper.'" The proud spirit of Naaman was, however, ultimately appeased by the pleading of his servants, who said, "My father, if the Prophet had bid thee do some great thing, wouldest thou not have done it?"

The lesson I wish to teach is, that many valuable sanitary works are extremely simple, and that also they are personal. Do not rely on costly works, or expect grand ceremonials, but put your house in order and obey the simple injunction, "Wash, and be clean."

ON HOUSE-ACCOMMODATION:

ITS SOCIAL BEARING, INDIVIDUALLY AND NATIONALLY.

From the "JOURNAL OF THE SOCIETY OF ARTS," *February 5th*, 1858.

THE paper now brought before the Society, is intended to direct attention to houses as they have been, to houses as they are, and to houses as they ought to be. The house-accommodation of the masses will be principally considered, some of its defects will be pointed out, some of the resultant evils will be described, and certain suggestions for means of improvement and of sanitary regulations will be made. The question of house-accommodation is far too comprehensive to admit of full discussion in the time allotted to one evening; and, therefore, disappointment may be felt that some particular branch of the subject has not been dwelt upon.

House-accommodation and house-construction have received the attention of His Royal Highness the Prince Consort, and also the attention of many noblemen, gentlemen, and ladies, who have followed the good example set them. "Model houses" and "improved cottages" have been erected by societies and by individuals, with beneficial results most encouraging. To remedy all existing defects in houses of the poor in such manner is, however, too much for isolated individual enterprise, and far too vast even for a free government. How, then, must the work be done? I will not attempt to give a full answer, but will content myself with pointing out some of the existing evils, and with showing how widespread these evils have been, and now are, and then briefly indicate a few practical remedies. Improvement must, I consider, consist in inspection, and in regulation, by the local authorities, wherever neglect, filth, and disease exist.

Particular plans of improved cottages will neither be described nor recommended, not because their appropriateness and advantages are not recognised and appreciated, but simply because there is not time to discuss the whole subject. I may be asked, "Why, then, open up the question?" My answer is, that in this great and free Christian country, knowledge must precede beneficial change,

and to inculcate the necessary knowledge there must be "line upon line, precept upon precept." Many good and able men have spoken and have written upon "the habitations of the poor," and many more good men must speak, must write, and must act, before the work will be even hopefully initiated. The question is one of health, of morals, of religion, and essentially one of national safety. If, as a nation, we will not work from higher and more Christian motives, our selfish fears may, in time, prevail. The health and life of a nation are in the masses.

A celebrated writer has said, if he might "write the songs of a people, he cared not who wrote their laws." I would say, "if I might house the people, I care not who writes songs, or who enacts laws." Good citizenship is not from without, but from within. If men and women learn immorality from their birth, and in their homes are surrounded with vice as with the atmosphere, of what practical use can any secondary means prove? National schools, national reformatories; private schools and private reformatories; must alike fail. Gaols do not improve the morals of criminals, but notoriously render them worse. Gaols are actually looked upon by many criminals with favour, and not with dread. Cottages are not so clean, nor so airy, nor so warm, nor so healthy, nor so comfortable as prison-cells. I do not say "neglect the gaols," but I do say, "look to the cottages, to the birthplaces, the homes, the true schools, and the only practical reformatories for the poor."

Historic Sketch of Houses.

The earliest form of protection for the human body from the effects of climate, would most probably have been a "gourbie" or a tent. Caves would only be resorted to after crime had induced personal fear, and rendered seclusion necessary to personal security. The tent of the Arab is, to this day, as were the tents of the patriarchs. Typhes of house-construction may probably be found, in use, in one part of the inhabited globe or another, which faithfully represent every contrivance for shelter either invented or appropriated by man, from the burrow of the bushman to the "solemn temples" and "gorgeous palaces."

Invention and progress seem to be confined to a few of the many races of men, and progress, with permanence, has, so far as we know, as yet been the lot of none. The much-vaunted Anglo-Saxon race is only on its trial—and, if Lord Macaulay's prophecy should come true, we know its fate. Look abroad over the wide and fruitful regions of the earth, and we shall find retrogression in vast masses of the population, or superstitious forms stereotyped. As the Chinese were in ages past, so are they now. Throughout the East, generally, we find desolation or barbarism, where civilization once reigned.

In these regions, from the earliest periods of history, and under every form of government, we find that the masses of the people have been badly housed, and hence have occurred plagues, pestil-

ences, misery, and premature deaths. The history of man, with few exceptions (the Jews, Egyptians, Romans, &c.), down to the present time, is indeed one of neglect of sanitary laws, and consequently of retributive punishment. The Registrar-General points out weekly, quarterly, and annually, the national mortality, indicating the preventible excess, but, so far, to little practical parochial or municipal purpose, as compared with the work required to be done. Ignorance is fenced round with selfishness; the desire is to protect property and pocket; the results are ruin to property and to health and morals; the sacred name of freedom is invoked to perpetuate a state of things which breeds vice and engenders crime. An Englishman's house is said to be his castle. When Englishmen learn to keep their castles (that is, houses) so as not to destroy their own health, and render themselves, their wives, and their families, a burden to the community, they may be left alone; but a man cannot be allowed to keep at large a savage dog, or a mad bull, to worry, to tear, and to gore the public. Why, then, should any man be allowed to generate and let loose typus, small-pox, and other analagous diseases, to disfigure, and to destroy? Lord Shaftesbury, by his "Common Lodging Houses Act," has given the means to prevent disease and to diminish immorality, wherever the Act is put in force, and the beneficial results are acknowledged alike by landlord and by tenant. Let there be such power of inspection, wherever contagious diseases break out, whether the house be that of a rich man or that of a poor man, and the results will be a benefit to all. Several towns have had public and private works of sewerage and drainage carried out with most marked beneficial results; but back streets, courts, and alleys remain neglected, room tenements and cottages (not common lodging-houses) remain overcrowded, unventilated, filthy, and breeders of fever. The parish authorities can only relieve distress brought about by preventible disease; they cannot, or they do not, remove the causes of the disease.

Houses as they have been, and Houses as they are.

Central Asia—the birth-place of truth and of myth—the cradle of history—the land of contrasts—presents us with the oldest type of human dwelling; and what do we find but, side by side, the most wretched hovels and the most luxurious palaces? In the hovels we find the Arab-Egyptian (the Fellah), the "Ryot" of Hindostan, and the swarming masses of China, who all fare badly. A hut of mud, a roof of thatch, a floor of filth, hovel and clothing abounding with parasitical vermin, where skin diseases, ophthalmia, along with other analogous complaints prevail. From generation to generation there has been, and there continues to be, the greatest amount of misery to the greatest numbers. The tropical sun shines down upon filth, upon squalor, and upon disease. The vulture, the stork, the dog, and the hog scavenge the streets and suburbs as of old; and at a glance you may see that the existing dog of an Eastern city is a lineal descendant of those dogs which licked the blood of

Ahab, and ate the carcase of Jezebel beneath the wall of Jezreel. Plague ever broods over these sites, and cholera sows its subtle but death-producing seeds in the face of the sun, to be wafted wide as the atmosphere, to kill wherever there is degraded man, living amidst filth, foul-air, and wallowing in sin.

The Russian serf is miserably lodged; the habitations are of rude materials, are primitive in form, and wretched in accommodation. Over the continent of Europe, generally, the poor are lodged in mere hovels, with defective means of sunlight, with defective means of ventilation, and filthy alike internally and externally. Examine the tenements of Germany, of Denmark, of France, of Italy, of Portugal, of Spain, and of the other kingdoms, and you will see the appropriate residences of ignorance and superstition; the fitting birth-places of wild turmoil and anarchy.

But, as Englishmen, let us look nearer home,—let us blush and sorrow over the mud-hovel of Ireland, the "boothie" of Scotland, the country cottage, and the room-tenement of England. I have seen these places, and have witnessed sights I cannot describe, and human misery the pen fails in power to depict. The story of this source of national deterioration has been told recently by many able men, as may be found in despised blue-books, and in literature not popular.

If we look to our mediæval history we find that our cities, towns, and villages, for the most part, were composed of hovels with mud-walls and with thatched roofs. Mud floors were covered with rushes or straw, which remained until the compost was rotten to corruption. Houses were without order or regularity. Streets, in cities and in towns, were narrow, dark, and tortuous; the subsoil was without sewers and drains; the streets were without pavements and lights. Dogberries watched but did not ward, bravoes stabbed, burglars plundered, and nimbler thieves "cut purses." The only remedy known to the magistrates consisted in loading gibbets, and in "stringing sturdy rogues to the gallows apace."

Time rolls on, and "merry England" grows into the improved state depicted in Swift's "City Shower." Parts of cities and towns had then pavements and surface gutters, but no sewers. There are now pavements, sewers, cleansing, lighting, and watching more generally; but many a poor man's cottage, and many a room-tenement receive no adequate benefit. There is scarcely a city, town, or village in Great Britain in which there are not to be found some houses and some rooms into which the sun seldom shines; into which a breath of fresh air seldom blows. There are courts closed all round; alleys not two yards wide; rows of cottages back to back; rooms without window or flue; cellars, with ceilings below the level of the ground; attics in which a child cannot stand upright, and inhabited human dens too foul for wild beasts' lairs.

There are many reasons for the utterly degraded state of this portion of our poor. Centuries of neglect and of seasoning have blunted the natural senses to the taint of foul air; as, most frequently, the only industry shown is to block out fresh air, to secure

heat—and when we find thousands of men, women, and children in our towns, barely covered by a few filthy rags, inhabiting rooms without furniture, lying on rags, or on tainted straw, with no adequate food, and no certainty of a second meal, except by begging or by stealing, we should judge their ignorance of sanitary laws lightly, and deal gently with their transgressions, as most of these poor creatures never had a chance given to them of knowing better or of being better. They cannot build houses, they cannot furnish a single room, however small; they cannot understand the laws of nature; they cannot appreciate oppressive sanitary rules, when arbitrarily enforced. They are hungry, and wish to eat; they shiver in the cold, and wish for warmth; they are exposed to the bitter elements of a severe and varying climate, and they wish for shelter. A living body is warmer than a naked wall or bare floor, and hence overcrowding is considered a desirable thing. They feel and appreciate the warmth, but do not see the subtle poison; and, in fact, the carbonic acid deadens the senses, and induces oblivious repose.

The reports drawn up by the Inspectors of the General Board of Health and others detail case upon case of defective house and of improper room accommodation. I could add proof upon proof from personal inspection, of the discomforts, sicknesses, and miseries endured by the poor who reside in cellars, damp, fœtid, and dark at noonday; or who huddle together in room-tenements which are without furniture, the floors rotten, the walls blacked with filth, the ceilings hung with webs of spiders, and out of which rooms fresh air is, as much as is practicable, excluded. There are the rubble walls of the north, the porous bricks of the midland counties, the "cob" walls of Devonshire, and the rotten timber and shingle of some of our seaports. Out of these places proceed fevers; and upon them settles cholera. Into them goes the parish money, as the relieving officer and the parish surgeon cannot long be absent. The rent is paid by the parish many times over, and not unfrequently more than the purchase money is expended in one year. There are room-spaces of the most wretched class, which annually cost a parish more to maintain than any equal area in Windsor or in Buckingham Palaces.

The Registrar-General has stated that the tendencies of modern civilization in this country are to mass men into towns. In 1841 the population in 117 districts, comprising the chief towns, was 6,612,958 souls. In 1851, in the same districts, the number was 7,795,882, being an increase of 1,182,924 in ten years, or about 18 per cent. There is a corresponding increase in the rates or mortality, although in some cities and towns there have been many sanitary improvements. As towns increase, there is an engulphing or lowering of whole streets and of entire districts of houses, built originally for the merchant and superior tradesman. Examine some of our great sea-ports and inland manufacturing towns, and it will be found that streets of houses originally erected for "the merchant princes" are now in ruins. From having been the abodes of those possessing wealth, they are now the abodes of the

improvident, of the vagrant, of the vicious, and of the unfortunate. The quaint carving on the stone-work looks out of place, the walls are half in ruins, the gables are shattered, and foul weather-stains of damp blotch the surface. Within, matters are even worse: the rooms are now divided and sub-divided on every floor; the staircase is darkened, its massive hand-rail and carved balusters are crippled and broken; the once firm stairs are now ricketty and dangerous; the stucco-finished plastering is blackened and in holes, the dusty and rotten laths being in many places bare; the landing-windows, when the space is open, have neither frame nor glass, so that the rain drives in right and left; make-shift doors lead into small spaces let off as separate tenements. The narrow space of street betwixt the houses is further contracted by rude looking poles rigged out of windows on either side, storey above storey, on which clothes are hung to dry; thus, externally, a free flow of air is impeded, and an atmosphere, usually very damp, is made more so. In the same street houses may be found which were erected in Queen Elizabeth's reign, with others of more modern date; the walls are of hewn stone, of bricks, of timber framing, of limestone rubble, or of other material. Some have been plastered, and others have been covered with slates; some have plain vertical fronts, and others project at each storey. Out of these streets covered passages lead into still narrower, dirtier, and more crowded courts. In many instances the ground rises abruptly, and slippery, half-worn steps lead to houses more ruinous and more crowded than those fronting the streets. One privy serves for a whole court, and this is usually filthy; the cesspool full, overflowing; the fœtid refuse stagnant over the surface. An external standpipe, the water on only for one hour in twenty-four, supplies water to an entire court with many tenants; tubs, mugs, pots, pans, and troughs, being placed in yards, on stair-landings, or in the filthy rooms, to absorb all the deleterious gases of the places. Within, the furniture accords with the premises—it is old, rotten, broken, and ruinous. One room serves for a family of father, mother, and children, not unfrequently grown-up sons and daughters. Dogs and fowl inhabit the same small apartment, and in some instances ten human beings. In gaol each criminal has, at the least, one thousand cubic feet of fresh air secured, and the air in this space is regularly, evenly, and many times changed during each day. The inhabitants of room-tenements, of country cottages, of Scotch boothies, and of similar places, have frequently not one hundred cubic feet of air space, and this air is never changed, but by the natural law of diffusion of gases, the deleterious carbonic and sulphuric acids are allowed to perform their fatal work.

There are many defects in old and in modern villa and suburban houses, such as improper sites for detached houses, in the country or in the suburbs of towns. The site may be a swamp, an undrained hill-side, or even a hill-top. The sewerage and drainage may be defective; the plan may be confused; the rooms may be

too low; the doors, the windows, and the fire-places may be improperly placed; and means for ventilation may have been entirely neglected. The pump and the cesspool may communicate, and pipes and gutters, and cisterns of lead, may add that deleterious metal, in solution, to the water used for domestic consumption. There are few country or suburban houses, even of the better class, entirely free from some one or more of these defects—no, not even the mansions and palaces.

Having glanced at houses as they are, in courts, in lanes, in alleys, and in the back slums of towns, and at some of the defects of those in their suburbs, we will now look at some houses as they are in the country throughout Great Britain.

Cottages.

Look at these structures called cottages. They are mere hovels of mud; or of "wattle and daub;" or of rubble stone set in mud; or of rude timber-frames filled in with mud, or with brick, or with stone, or with other material. The timber is rotten; the mud, bricks, and stones, are damp in wet weather, and dusty in dry weather. Look at the site; probably a hole—not unfrequently a swamp several feet below the adjoining road, the slope being towards the door. If on an elevation, the ground is unformed, rugged, abrupt, uneven, and neglected. Many of these hovels are only one story in height, the side walls are very low—from three to six feet up to the square—few are vertical, and some are supported by buttresses or by props. Many are half-buried against a hill-side, or against a bank which is wet.

Then the roof. This is thatch of heather or of straw; or is formed of turf, of sods, or of shingle, of tile or of slate. If of thatch, the material is rotten with age, and green with fungoid vegetation; if of shingle, the timber is decayed; if of slate or tiles, they are broken and in holes. Doors and windows match the structures, and the floor is native mud, the space enclosed being common to bipeds and to quadrupeds alike. The floor is not only very dirty, but the walls, roof, and furniture are the colour of grimy dirt. Amongst the rafters, spiders and other insects abound. Outside, animal refuse is stored in some hollow where liquid permanently rests, so as to keep up evaporation and an evolution of gases highly injurious to human life, and if this refuse does not actually surround the hovel, it is frequently so situated that the prevailing winds shall drive the gases of decomposition into and through the habitation. The arrangements for disease, misery, and premature death are ample, adequate, and complete. The hovel is crowded by males and by females of all ages, without means of separation, so that the arrangements for sin and misery are also complete. Morality is consequently at a low ebb. How can it be otherwise? Look at the country in which these hovels are situate. There may be the grand old mountains of Wales, fragrant with heather and wild flowers; there may be the glorious

lake scenery of Cumberland; or there may be the graceful undulations of the midland counties, agriculturally rich beyond the romance of fable—trees, corn-land, and grass-land blending harmoniously; or we look over the wolds of the chalk and oolitic district, open in broad rounds and valleys, dry and comparatively bare of trees, but, nevertheless, yielding rich herbage and fine crops. Such hovels as I have faintly attempted to depict may be found in landscapes such as I have most imperfectly attempted to describe, but the houses are neither ornamental nor useful, although artists persist in designating them picturesque. There are not only agricultural hovels, but there are sea-side fishermen's hovels, and out-of-the-way miners' hovels. They are, however, all of one type, and are too frequently nests of filth, of foul air, of sickness, of immorality, of human degradation, and of human sorrow. The parish doctor knows the inhabitants; they consume his time and his physic. The relieving officer knows them; they empty the public pocket. The parish constable knows them; they are his most turbulent customers. The gamekeeper knows them, as frequently they are poachers. The magistrates know them; they commit petty thefts, and produce bastardy cases innumerable. The minister of religion knows them, as most assuredly amongst these people his principal work lies. The charitable know them; ladies, beautiful, delicate, and good, visit, sympathise, and relieve.

"Hovels, and their inhabitants, as they are," such as I have tried to describe them, are known and they are unknown. They are known to artists, to parish surgeons, to constables, to gamekeepers, to some clergymen, and to benevolent ladies, but they are, for the most part, unknown to parish guardians, to town-councillors, to country squires, to imperial legislators, to the general public, and to very many landowners. By some landowners their existence is considered to be an incumbrance. Cattle have value for such persons, but not human beings.

Scotch Highland and Island Boothies.

The cottage, boothie, or hut in Scotland is a barbarous shelter. Many of those in the highlands and islands are mere hovels, rough in the materials used, and rude in the form of construction. The side walls and gables are of dry rubble stone, peat, or mud; the covering is thatch, mud, or sod, often a jumble of material, plastered, piled, weighted, or tied on. The door is low: a mere hole serves for window; and a hole in the roof lets out a portion of the peat fire smoke. There is no flue, and, consequently, when the fire smokes, there is a general distribution of smoke with the heat, so that a philosopher may study the law of "diffusion of gases" visibly. Smoke not only rises through the hole specially left for its escape, but pours out of door, window, and also out of every crack and cranny in roof and side wall. A stranger might easily imagine that the boothie was on fire, or mistake it for some charcoal-burning apparatus or kiln. The inside of one of these

boothies is a curiosity. There is an attempt at division, and beds are made up in recesses of the smallest dimensions against the damp walls or bank, and closed in by the aid of peat, hurdles made of heather, or some equally rude contrivance. If there are ceiling-joists, a loft is made in the roof, to be reached, not by stairs, but by a ladder, and this may be a general store or a bed-room. Most frequently the natural earth—be it rock, mud, or peat—forms the floor, full of holes, worn and uneven. Pavements may be found of rude flags or pebbles, or a mixture of both. Many boothies give shelter to cattle and other animals which man retains for his use—quadrupeds and bipeds—such as dogs, pigs, ponies, ducks, fowls, &c. They may enter all by one door, or there may be a separate entrance under one roof. Inside and outside these places there is dirt and neglect. The very spirit of thrift could not, in fact, keep such places clean. Smoke is as the breath of life to the residents, damp and dirt an institution.*

We censure the poor for their indulgences, but what says that close observer of human nature, Sir Walter Scott. Listen to the antiquary and the village fish-wife, after the bargaining for the fluke and the cock-paddle.

Monkbarns says :—

"Half-a-crown, then, Maggie, and a dram."

"A weel, your honour—maun hae't your ain gate, nae doubt, but a dram's worth siller now, the distilleries is no working."

"And I hope they'll never work again in my time," said Oldbuck.

"Ay, ay—it's easy for your honour, and the like o' you gentle-folks, to say sae, that hae stouth and routh, and fire and fending, and meat and claith, and sit dry and canny by the fire-side; but an ye wanted fire, and meat, and dry claise, and were deeing o' cauld, and had a sair heart, whilk is worst ava', wi' jist tippence in your pouch, wadna ye be glad to buy a dram wi't, to be eilding and claise, and a supper and heart's ease into the bargain, till the morn's morning ?"

Charity is inculcated in the Scriptures; and it must not be denied that charity is necessary to Christianity. But there are many forms of false charity, and some of these forms are demoralising. It is not charity which leaves a labourer and his family in some wretched cottage or hovel to contract and to endure fever, and then to relieve him with wine, jellies, and similar delicacies. It is not charity to allow the poor man's home to be all discomfort, so that the ale-house leads him from bad to worse, or until a gaol receives him from the esquire's sentence, and then for the esquire's lady and daughters

* Up to the early part of Elizabeth's reign, cottages in England generally consisted of a single room, and chimneys were unknown in such dwellings. Up to the end of the 13th century, castles (or baronial dwellings) were fortified places, in which the convenience of habitation was sacrificed to purposes of defence. It was not till the 15th century that barons resigned the security and gloom of their fortress-castles for the comparatively greater comfort and convenience of castellated houses.

to carry or to send relief to a broken-hearted mother and starving family. Soup-kitchens, charity-bazaars, money-clubs, clothes-clubs, dispensaries, and personal visits to distribute money or food are not to be denounced; but they should all be secondary and not primary; the duty of the rich is to help a poor man to help himself. Firstly, by providing comfortable and healthy homes; and, secondly, by living such a life as shall be a good example; a clean, well-ventilated, and well-drained cottage, with good water, and a small garden, at a moderate rent, should be provided. A case of fever should lead to an immediate inspection, and to immediate sanitary improvement; other forms of relief may then be consistently offered. It is a mockery, if not worse, to allow a man to inhale poison, and then to offer him sympathy; intoxicating drinks and delicate food do not cure fevers, but fresh air and wholesome water, with plain food, well cooked. Promote means of health, promote means of industry, and promote habits of forethought and habits of economy; add to this relief to the aged, and especially the afflicted, that blessings may rest on the giver and on the receiver. Many richly endowed charities are a perpetual curse; many so-called charitable people sow the means of vice broadcast; schools, churches, union workhouses and gaols, will neither cure nor even reduce the evil; there must be the means of health and comfort, with a chance of virtue, in every British home before men can be Christians.*

Ventilation of Houses.

Many volumes have been published on the subject of ventilation, and many patents have been granted for apparatus to effect ventilation: and yet, one of the evils most common both in public and in private buildings is defective ventilation. How is this? The nature and properties of the atmosphere have been accurately described over and over again, and correct means of ventilation are lucidly set forth by more than one author,—from Count Rumford to Dr. Arnot; but, somehow or other, the right knowledge does not get into the right heads,—hence all the neglect or blundering, all the mischief, and all the consequent misery and inconvenience. With the wheat of knowledge there is a vast amount of the chaff of ignorance and of advertising quackery. Architects and builders must be very young birds indeed if they are caught by the chaff of ventilating adventurers. But the truth must be told, namely, that few architects make ventilation a special study, and they consequently neglect alike both wheat and chaff; ventilation has not been "in the bond;" they design and build a house, having doors, windows, fire-places, and chimneys; but there is no warranty given that the rooms shall have full and free means

* When fever or small-pox occur in villages, any large empty farm or open cart-shed may be used as temporary hospitals. Protect the patient from damp, wet, and direct drafts of wind. Keep him warm by clothing, but do not fear the fresh air, as it will be the best medicine.

of ventilation, independently of doors, windows, and ordinary chimney-places, or even that all the flues shall draw. Will it be improper in time to come to ask for such warranty? All rooms ought to be ventilated; all chimneys ought to draw. The task may be difficult, but it is not an impossible one; smoke obeys the simple law of nature under all circumstances and on all occasions; it never comes down, when it ought to go up, without good and sufficient reason; if there is fault it is in the building or in the architect, and not in the smoke. It may be pardonable to attempt once more, probably in a more bungling manner, that which has been so often and so well done by some of the great men alluded to, viz., to explain some of the properties of the atmosphere.

Air is a substance highly elastic, but, under equal temperatures, its bulk and gravity are tolerably permanent.

Heat expands air, causing it to occupy more space, and hence heated air is lighter in proportion to the heat imparted to it.

Warm air, being lighter, rises into and through colder air; and cold air, being heavier, descends into and through warm air; that is, the warm air from a room and chimney rises into the colder air outside, and there is a tendency in the cold air to descend into the warmer air of the room, even down the chimney, if the balance of the draft is not in favour of an upward current. When rooms contain air several degrees of heat above the external atmosphere this colder and heavier external atmosphere presses in to restore the balance, through every chink and opening; hence the cold drafts experienced in winter.

To maintain combustion air is necessary; hence the abstraction of air by all fires, and the necessity of chimney-flues to remove the heated products of combustion.

All rooms are reservoirs of air; they contain so many cubic feet, according to their dimensions. A room 10 feet long, 10 feet broad, and 10 feet in height, contains 1,000 cubic feet of air, at all temperatures, neither more nor less. But, as air is expansive and is expanded by heat, 900 cubic feet at a low temperature may be heated until they are increased in bulk to 1,000 cubic feet at a higher temperature. In this case, as there is one-tenth less of substance, there is also about one-tenth less of weight, and one-tenth less of the chief ingredients to nourish life. The warm air is one-tenth lighter, but in each case the room is full of air.

For the sake of illustration, we will compare the room full of air to a cistern full of water (though water is practically non-elastic). Then, to maintain either a room full of air, or a cistern full of water, if provision is made for drawing out (or abstracting like a chimney-flue), provision must be made for letting in. If doors and windows fit tight, and there is no other means of admission, it will be practically impossible to abstract air by the fire and chimney-flue from a room for any length of time. The operation could not go on for an instant, but by reason of the elasticity of the atmosphere. Few rooms have doors and windows, walls, floor, and ceiling perfectly air-tight, and hence a fire is burned at the expense of cold drafts,

wherever external air, in winter, can find entrance. This is generally under the door, through the skirting and floor, and so along to the fireplace. Who does not suffer from cold feet in the winter, especially during frosty weather?

Small rooms, having less air to pull upon expansively, frequently smoke by puffing down-drafts in the chimney. The fire forces air up the flue, until the air is too highly rarified, and there is practically a partial vacuum; cold air then descends the flue to restore the balance, forcing some of the heated air and smoke with it. Large rooms, as a rule, are more easily warmed, and are freer from draughts than small rooms.

There is one form of evil connected with houses, namely, the admission of foul gases from sewers, drains, or cesspools, which, being unseen, may remain unrecognised although much sickness and many premature deaths may occur in consequence. At all times when the internal temperature of any house is higher than the external air, there is an active exhaustion caused by the fires up the chimney, and there is a drawing or pumping power within the house, and sewer and cesspool gases are drawn in from every crack and from every cranny. The mischief of such a state of things is very great. In forming sewers and drains, this contingency should never be lost sight of. Defective sewer and drain connections are a source of mischief both winter and summer, as in winter the foul gases are drawn in, and in summer sewer gases (sulphuretted hydrogen) and others, which are lighter than common air, flow in. Many persons think that houses situate on a hill, or having a rapid fall for the drains and sewers, must necessarily be easily drained, this is a mistake; there must be special and ample provisions for external ventilation from the sewers and drains, or the gases from lower levels will flow up and into such houses. Water, by reason of its weight, which is greater than atmospheric air, flows down hill with velocity proportionate to the slope and to the friction; sewer gases, by reason of their gravity, which is less than atmospheric air, flow up-hill with velocity also proportionate to the slope and to the friction. It is of the utmost importance that these facts should be remembered.

There is the law of "diffusion of gases," by which gases diffuse throughout other gases and throughout atmospheric air. If this law were annihilated, the present order of animal creation must cease to exist. It is the diffusion of gases which renders a hut, boothie, cabin, room, common lodging-house, or modern drawing room, tolerable during excessive crowding. The poor over-crowd their wretched apartments partly from ignorance, but more from stern necessity. The wealthy crowd a modern drawing-room partly from ignorance, but more because it is fashionable. The mischief is alike fatal in both case. At a dinner table we have our plates and knives and forks changed, and use separate glasses for purposes of drinking, but in a crowded drawing-room, and in a crowded ball-room, we breathe and re-breathe the waste products of our own and of each other's lungs, vitiating and re-using the air

in common, a process far more injurious to health than using plates and glasses in common. Ventilation, free and abundant, should, in all cases, be provided for. But no amount of ventilation will do away with the evils of overcrowding. An overcrowded hovel, or an overcrowded drawing-room, is only an evil in a lesser degree.

The following extracts from Reports by the Inspectors of the General Board of Health will give some idea of the sanitary condition of the dwellings of the poor in the towns named.

The supplement to the Report on Whitehaven, dated 1849, contains tables of the "room-tenements" and "cellar-tenements" within the district, and states that "the buildings are in a ruinous condition; the staircases are of wood, frequently dark, confined, and rotten or out of repair. When the beds are described as 'old and dirty,' they are upon bed-stocks, but very few of them have anything to cover them with but a bundle of old rags. Those beds, named 'rags and straw,' are on the floor without bed-stocks, and without proper bedding to cover them with; the bed-clothing, if any, a bundle of rags. Many of the rooms are swarming with vermin; disease and fever prevail throughout."

Out of 315 room-tenements, inhabited by 1,369 persons, there are 256 described as being without means of ventilation. The beds in 83 of these tenement are composed of "rags and straw," and nearly the whole of those in the remaining tenements come under the headings of "dirty" or "old and dirty."

Out of 191 cellar tenements, occupied by 716 persons, not less than 177 are stated to have no means of ventilation. "They are damp and dirty to a degree not to be described; a heap of dirty straw or rubbish constitutes the only form of bed in most cases, and this is laid on the the damp floor in one corner. The confined smell and fœtid atmosphere are most offensive, and almost suffocating to any person entering. They have no privies, or convenience for ashes, but the inhabitants get rid of their refuse as they best can, most frequently immediately in front of their door." It may be added that 12,000 of the inhabitants, or two-thirds of the entire population, were, at the date of the Report, without any privy accommodation.

In the Report on Gateshead, speaking of the dwellings of the poor, the Inspector says—

"Neither plan nor written description can adequately convey to the mind the true state and condition of the room-tenements and of the inhabitants occupying them. The subsoil on the sloping side of the hill is damp and most foul; the brickwork of the buildings is ruinous, the timber rotten, and an appearance of general decay pervades the whole district. The buildings, originally erected as residences of a superior description, have single rooms let off as tenements, which are crowded with men, women, and children; the walls are discoloured with age, damp, and rot; the windows are broken; old rags, straw, and boards, occupy the place of glass, so that means of light and ventilation are alike absent. There are no sewers nor drains, neither is there any proper (privy) accommoda-

tion; solid filth encumbers the surface; liquid refuse saturates the subsoil, and is drawn by capillary attraction through the porous bricks up into the walls; personal cleanliness or a healthy atmosphere is impossible."

In the Report on Dover, the following evidence of the Relieving Officer of the district is given:—

"The largest proportion of out-relief distributed in the worst portions of the district is caused by fever, small-pox, and other similar complaints, such being very prevalent in these localities; caused, I have no doubt, to a very great extent, by the closeness of the buildings, and their filthy state, from want of proper drains and other sanitary regulations.

"From the experience of upwards of ten years' intimate connexion with the poorer classes, I have not the slightest hesitation in affirming that there is a most decided direct connection betwixt confined districts, bad sanitary arrangements, and poverty and vice. In the worst districts the moral state of the inhabitants is most deplorable; as the youth from these places grow to manhood they become habitual theives or paupers; brought up to no regular employment, grossly ignorant and reckless, their time is spent between the gaol and the union workhouse. I can only say that if the Government wish to prevent the increase of a most debased and vicious population they will take measures, if not to sweep away these nests of vice and disease already built, at any rate to prevent similar places from being erected in future."

The Rev. T. W. Darwell, Curate of St. James's Parish, Dover, says—

"My own observations and experience in visiting among the poor, tend most decidedly to confirm the evidence that better sanitary regulations would tend very materially to improve the habits of the people. The poor man, when fatigued, cannot be expected to remain in his house, if his wearied senses are to be oppressed by noisome stenches and disgusting objects. He naturally seeks the beer-shop as a refuge, and his wife and family are left to seek relief, under such circumstances, as they may. Thus the domestic bond is loosened, if not severed; he ceases to regard his family, and they cease to respect him, and so a generation of reckless and unprincipled persons is by these means turned out upon society."

The Rev. J. Puckle, Incumbent of St. Mary's, Dover, in a letter addressed to the Superintending Inspector, in 1848, says—

"From a ministerial experience of 13 years, I am perfectly satisfied of the close connection subsisting between the sanitary and the moral condition of our poorer classes. I have found, without any exception, the worst demoralization in the worst constituted dwellings and neighbourhoods, the one being traceable from the other, directly, as effect from cause. To what extent we may ever succeed in raising the moral tone of our poor people's habits of life, time only can show; but I affirm, in conscience, that to raise them while they live in such places, and under such circumstances, is impossible."

The Relieving Officer of the Falmouth District, in his evidence given before the Superintending Inspector, says—

"I pay in out-door relief from £8 to £9 per week in the district; in the town of Falmouth about £5 a week. Have seen fever in the places I visit. Pay most relief in the worst places. Sometimes continue payment five or six weeks to one family, and as much as seven or eight shillings a week. Much of this disease might have been saved if fever could have been prevented. See much misery. The people do not complain so much as we complain of the nuisances. Had extra relief to pay for cholera in 1848 and 1849, and pay to this day (1854) to some of the families made paupers by the cholera."

The medical officer to the Falmouth Union states:—

"Fever prevails in most of the courts. It is invariably found with dirt. Where there are defective ventilation and bad drainage there we get fever. Many of the bed-room windows will not open. The rooms are about twelve feet by ten feet, and seven and-a-half feet high. Ten persons occupy such rooms. Have been obliged to knock out a square of glass in a window to get ventilation. This overcrowding lowers the standard of morality. Much disease is traceable to intemperance. Men are driven from an uncomfortable home to the public house."

The following extracts from the "Report of the Commissioners appointed to inquire into the causes which led to, or which aggravated the outbreak of cholera in Newcastle-upon-Tyne, Gateshead, and Tynemouth," show the bad sanitary condition of the dwellings of the poor in those towns in 1853.

Speaking of Newcastle, the Commissioners say:—"There are considerable districts, especially in the lower and older parts of the town, in which almost all the houses are built back to back, so as to be incapable of thorough ventilation, and with their fronts within so few feet of one another as to render it almost impossible for sunshine, wind, or rain to reach directly even their exterior walls; many of these miserable lanes, or entries, being moreover closed up or covered over at one or even at both ends.

"That on entering some of the houses in such localities during our day inspections of the town, we were arrested at the door by a darkness which was little less than total; and medical officers are sometimes under the necessity of taking a candle in order to see their patients in some of the rooms in these places, even at noonday, and in the height of summer.

"That the poorer inhabitants are not only very ill-lodged, but exceedingly over-crowded in their lodgings. That about half the families in the town are confined to the occupancy, or joint occupancy, of exceedingly over-crowded single-room tenements. That in September, 1853, cholera broke out in rooms in which as many as twenty to twenty-five occupiers were congregated; there being only fifty cubic feet of space or air (furniture, &c., not considered) for each individual. That in consequence of the frequent ill-construction, ill-ventilation, and over-crowding of the habitations of the

poorer classes, as well as the want of sewerage, drainage, proper domestic conveniences, and other matters, the condition of many of the tenements which form the residences of about three-fourths, and especially the condition of many of the single-room tenements which form the residences of about half, of the entire population, has habitually been 'filthy and unwholesome,' even where not technically described as 'unfit for human habitation;' that the stench experienced on entering some of them is in the highest degree offensive; and that the effects upon the health of the inmates, and of the vicinity generally, can only be equalled by the corresponding effect upon their morals and want of sense of decency."

The Commissioners state that there are 15,000 families, or not less than two-thirds of the population of the town, who have no right of access to a private "privy;" and that ash-pit accommodation is almost equally deficient.

The Commissioners close their report, as regards Newcastle, with a statement of the pecuniary loss sustained by the ratepayers, as the result of the outbreak of cholera. "The Board of Guardians expended, for immediate services, about £4,000; between £6,000 and £7,000 were expended under the supervision of the Vicar; an excess of at least £3,000 above the usual expenditure for sick and funeral moneys was incurred by the benefit societies; £500 were expended by the Town Council; an annual expense of about £2,600 was incurred by the Board of Guardians, for the maintenance of widows, orphans, and others, which at only eight years' purchase would be worth some £21,000; making altogether an expense of some £35,000, or thereabouts, over and above the very serious loss to the town from stoppage of trade, &c."

With regard to Gateshead, the Commissioners state—"That the same radically bad system of house-construction described as prevailing in considerable districts of Newcastle, prevails also, and probably to a larger extent comparatively, in Gateshead; that a large proportion of the houses occupied by the poorer classes (who apparently constitute four-fifths of the entire population, are built back to back, with one another, or when not actually back to back, with back yards between them so small as to serve only to receive accumulations of filth, and to be quite inadequate for wholesome ventilation; that the spaces between the fronts of these back-to-back rows of houses are so narrow as to render it almost impossible for either sun or wind to get at them, and to render them habitually dark and unwholesome; that one or other end of these narrow alleys is not unfrequently closed or built up, whilst in some cases, smaller lateral *culs-de-sac* are found leading out of a larger one; the other ends of these miserable places being also sometimes built over, so as to leave nothing but a single covered way for ingress or egress; that in other cases the houses are built into the abrupt riverward slope or bank, so as to have one or more of the walls, for one or more storeys in height, in close proximity with the earth of the acclivity above—while in some instances both these evils are combined; and in this way, throughout considerable

districts, chiefly occupied by the poorer classes, ventilation is rendered almost impossible.

"That a large part of the dwellings of the poorer classes are not fit for human habitation; that at least one-half of the population of Gateshead is thus dangerously mis-lodged; that a considerable part of those dwellings are not only not fit, but incapable of being rendered fit for such a purpose.

"That the poorer classes of Gateshead are not only exceedingly ill-lodged, but also much overcrowded in their lodgings; that it is an habitual thing for an entire family to live, sleep, cook, eat, wash, &c., in a single room; the corners of single rooms thus occupied being occasionally further sub-let to other families or lodgers." With regard to privy accommodation, the Commissioners state that Gateshead is as deficient as Newcastle, whilst in one point it is even more deficient, viz., in not having a single public privy.

With reference to the cost of the epidemic in Gateshead, the Commissioners say, "That an expense of about £1,278 was incurred by the Board of Guardians for immediate services; that a public subscription of about £600 was similarly expended; that an annual expense of about £450 was incurred for the maintenance of persons thereby rendered chargeable to the poor rates, which, at only six years' purchase would amount to £2,700; so that, without considering the loss arising from stoppage of trade, &c., the cost of the outbreak amounted to some £4,600."

Conclusions.

A close study of house-accommodation, especially for many of the poor, not only of this country, but of all countries, has led me to the following conclusions:—

That, as a rule, men so construct their habitations as to vitiate the common atmospheric air, rendering the free breath of life a fruitful source of disease.

By placing houses on improper sites.

By leaving those sites unformed, undrained, unpaved, and uncleansed.

By using improper materials for houses, and by adopting unsuitable plans.

By totally neglecting adequate means to secure ventilation.

By overcrowding, by indiscriminately mixing the sexes, and by allowing the adoption of habits of filth.

That the results in all ages have been fevers, plague, and all the analogous diseases which destroy infant life, and which cut off adults.

That there may be portions of the earth's surface unfitted for the use of man, but that, as a rule, the sources of disease are not so much in countries, in climates, in sites, in elevation, in density of population, or in any other external cause, as within the walls and beneath the roofs of the houses and tenements. Masses of people, living contrary to the simple laws of nature, are necessary

to decimating epidemics, and not peculiar climates, geological formations, great rivers, river deltas, inland plains or mountains.

That fresh air is the first requisite to health, and that any houses which do not admit of fresh air being breathed by the inmates—waking and sleeping—are defective in construction, are also defective in arrangement, and probably most defective in personal management.

That the poor cannot provide themselves with houses suitable to health, but must inhabit such as are placed at their service.

That many of the poor, and many working men, can afford to pay a sufficient rent for healthy cottages or rooms, if they had a choice, or could obtain healthy places of residence.

That, in many instances, the losses caused by defective house-accommodation, are both direct and indirect charges upon parishes; as foul air induces fever, fever destroys adult life, and then widows and orphan children become a parish charge.

Remedial Measures Proposed.

That in parishes, towns, and districts, there shall be an Inspector of Nuisances appointed; but that several small or poor places may be combined under one inspector, with the sanction of the General Board of Health.

That, upon an outbreak of contagious fever, small-pox, or other zymotic disease, the parish doctor, local medical officer, or local inspector of nuisances, shall have power to inspect the premises, and report to the local authorities.

That there shall be local power to insist on proper means of ventilation to all cottages and room-tenements; and that lime-washing may be ordered, or may be executed by the parish authorities, the cost to be recovered from the landlord.

That subsoil and surface-draining may be ordered, or may be executed when required.

That every room appropriated for human habitation shall have, at the least, one door and one window capable of admitting sufficient light, and that such window shall be so constructed as to allow of full ventilation.

That there shall be sufficient "privy" accommodation to all houses and tenements of not less than one seat to each five persons.

That there shall be means of external ventilation and sun-light to all dwelling-houses.

That there shall be means for a separation of the sexes in all houses and in all room-tenements.

An improvement in the law so as to facilitate the sale of land for house-building purposes, would afford means for improvement.

In new buildings, rooms to be inhabited should not be less in height from floor to ceiling than nine feet vertical.

All houses should have the roof-eaves spouted; and all yards, courts, and passages in the immediate vicinity of houses, should be paved, or flagged, and surface-channelled.

I have briefly and imperfectly treated a most important subject, and must now leave the question of improved house-accommodation to the consideration of our legislators and thinking men. The problem of house-accommodation deserves to be worked out. If defective houses were only inhabited by the needy poor, remedial measures would be imperative on Christians; but the case is more hopeful. Very many families earning good wages (from £1 to £2 per week) can obtain nothing better in which to live than a wretched hovel, a cottage in a blind alley, or a tenement up a narrow and dark court, or some miserable rooms or single-room tenement. The prices charged and paid vary from 2*s*. 6*d*. to 5*s*. 6*d*. per week; in the one case, £6. 10*s*., and, in the other, £14. 6*s*. per annum. It is practicable to build cottages in the country and in small towns, having four rooms, for a rent of £6. 10*s*. per annum, and to build blocks of houses in towns and cities, of equal accommodation, for a rent of £10 per annum, the common rate of interest being received in the form of rent; such houses to be properly sewered and drained, and to have wash-house and drying-ground—in common, say, to ten such tenements—to have a full supply of good water; to have "privy" accommodation adequate to privacy and decency; and to have means for ventilation and light to each room. In the country, garden allotments are a comfort, and a source of profit to landlord and to tenant alike, and a great blessing to the provider and the user. Ornamental cottages, if the ornament is costly, are not required. Improved dwellings and cottage allotments should not be made into show-places. An honest poor man does not require petting, but opportunity to be a good Christian, and to live by labour, and he is more likely, under such conditions, to be a good citizen.

Human society, to be stable, must be like the pyramid—the foundation must be broad, and it must be secure. The mystic priests of Egypt expressed their ideas in symbols, and I am not sure the pyramid was not intended to symbolise the construction of a nation. The broad, spreading base—the people; the diminishing, but rising courses—the middle classes; the upper courses—the nobility; crowned by the kingly apex; forming the only practicable finish to a symmetrical, secure, and enduring structure. The idea may be a vain fancy; but if Great Britain is to endure; if our civilization is to progress; if our religion is to bear appropriate fruit; if the great social evil is to be grappled with and subdued; the base of her society must be improved—the people must have the opportunity of health and of morality, that they may be both good Christians and loyal citizens.

The CHAIRMAN (the Right Honourable the Earl of Shaftesbury), in proposing a vote of thanks to Mr. Rawlinson for his able paper, remarked that he could speak with perfect confidence as to the merits of that gentleman, because it had been his pleasure to be associated with him for many years in works of this description. During the time that he (the Chairman) had the

honour of holding a seat at the Board of Health, Mr. Rawlinson was one of their Inspectors, and for diligence and activity, knowledge and zeal—not merely professional zeal, but influenced by deeply moral and humane feelings—he was unsurpassed. They were all acquainted with the valuable services he had rendered to the country as the Government civil engineer at Scutari and the Crimea; and he (the Chairman) was glad to find that he had returned fresh and vigourous, determined to devote his great energies to the improvement of the condition of the human race in his own country. He believed the announcement that the paper to be read was upon the social and national influence of the domiciliary condition of the people, had attracted a great many to this meeting, especially the ladies, and he could not but feel that, in his opinion, the paper was in strict keeping with its title. He was convinced that the domiciliary condition of the people was at the root of all moral and religious improvement. It was astounding to observe what effects good dwellings, with plenty of air and sunshine, had upon the morals of a community; they tended more than anything else to combat that monster evil—the vice of intemperance. He therefore thought the proper way to enter upon the discussion of this question was to begin with a statement of principles. He agreed with Mr. Chadwick, that in contemplating existing evils they ought not lose sight of the good that had been effected in this direction, in many of our large towns and in various quarters throughout the country, but the good that had been already effected only imposed upon them the duty of making still greater exertions to carry it on to its utmost limits. With regard to the erection of new dwellings for the working classes upon the best sanitary conditions in densely populated towns, where the price of land, labour, and materials was very high, he felt there was but small chance of doing so with a remunerative profit. They could not look for more than 6 or 6½ per cent., which the builder did not regard as a sufficient return for his capital. But, as had been stated this evening, very much might be done in improving existing buildings and localities, so as to render them fit for habitation, and this would, as almost every instance had proved, be attended with a remunerative return to those by whom the improvement was effected. The Chairmain then proceeded to explain the improvements which had been carried out in the localities of Wyld-court and Tyndal's-buildings, and mentioned the beneficial results that had accrued therefrom, in the elevation of the moral and social condition of the inhabitants. In the country there was a very great difference in this respect; the cost of land, which formed the principal item in large towns, being so much less, and labour and materials cheaper. Still he had found that he could not build a pair of cottages for less than £280, and a high rent must be paid in order to afford a fair interest for that outlay. What they required, therefore, was a cheaper but not less efficient mode of building cottages, with not less than three bedrooms, which he held to be indispensable for every family. Ventilation was a matter of the utmost importance, but the poor were found to

prefer warmth to pure air so strongly, that he had in some instances resorted to the stratagem of introducing a concealed ventilator in order to render their dwellings healthy. In carrying out improvements it was necessary that the tenants should peremptorily be prohibited from taking lodgers, or the existing evils would be increased. In conclusion his lordship said he felt the deep importance of the question under discussion, which he thought lay at the root of all that concerned the religious and moral state of the people, and he was certain that if they would use every effort to raise the poor to that condition which they ought to occupy as Christians and responsible beings, he, for his part, should have no fear either of the progress of infidelity or of democracy.

WHOLESOME HOUSES.

Letter to "The Times," January 6th, 1873.

To the Editor, Sir,—I find many persons sorely puzzled as to what to do to mend the sanitary defects in their houses. Will you allow me to suggest a few simple practical remedies? Many persons find offensive smells in the basement and a close stuffiness in the attics. A full and complete remedy would consist in an examination of the entire basement, to the end that every foul drain and cesspit should be removed, with any tainted subsoil, the whole being renewed with water-tight drains, and the subsoil covered with concrete. All rotten wood to be removed, and sound timber substituted. There is, however, no use in telling people to have these things done, or even to have all their drains pulled up and relaid; and certainly during this weather the remedy, for a time, might be worse than the disease. Kitchen sink-pipes and waste-pipes from cisterns usually pass direct to the drains, and the drains direct to the sewers, acting as flues for sewer gases. It need not be difficult to break the connexion of such pipes, outside the house wall, from the drain; and also to break the connexion of the drain or drains with the sewer, outside the house. This may easily and cheaply be done, and any plumber or builder ought to know how to do the work suggested. Basement rooms are seldom well ventilated, but a window in any room, opened an inch top and bottom, and screwed fast, if only open all night, when the room is not occupied, will give great relief. This need not be a difficult task to accomplish. Staircases and attics may be ventilated by windows, or by skylights, or by special openings made for the purpose. There must be means for the inner air to escape if the house is to be wholesome, as it is stagnant (used) air which is dangerous. "Heat will escape with the air." Of course it will, and cold air will enter in proportion to the warmer air let out; but in this change of air consists the benefit. Warmer clothing may be required even indoors, and must be worn, if health is to be preserved. Sitting-rooms may be preserved at or about 65 Fahr., but it is not necessary to maintain entrance hall and staircase at this temperature, neither is it necessary that ladies should wear low dresses and thin muslins in severe winter weather. Bedrooms, for persons in health, children especially, may have a low temperature and full ventilation, if the

bed is not in a direct draught, and the clothes on it are sufficient. A window open at the top is not a bad form of bedroom ventilation, and may be open as much as half an inch even in frosty weather. Persons in health, and many delicate persons, must always pass some of their time in the open air each day, and the less the amount of alteration in temperature the better. Manufactured air never can be fresh air; and therefore many forms of stoves, hot water apparatus, or other modes of warming houses by stoves, flues, and pipes, manufacturing and pouring in artificially warmed air, cause offensive sensations, and to delicate constitutions prove to be unwholesome. The ordinary open fire is no doubt the most costly, because most wasteful of fuel, but it is the most cheerful. Here, again, however, delicate and lightly-clothed persons complain of cold during frost; "they are roasted on one side and frozen on the other." Why do they not put on more clothing? A lady can sit in her shawl and an elderly gentleman in an extra coat. Better these expedients than to submit to overheated rooms, warmed by dried and flue-transmitted hot air, which unfits the lungs for external temperatures.

Entrance-halls, corridors, and staircases in large halls should be warmed, but should also be fully ventilated. No arrangement can be good which does not insure unceasing change. Vitiated air must escape that fresh air may come in, and, as vitiated air mixes rapidly with all surrounding air, there must be far more change than the actual volume of the air vitiated to secure safe dilution; as, so long as rooms are occupied, there cannot be purity, there can only be dilution in proportion to the volume of air changed—that is, passed out of the house and let into the house. It will probably seem superfluous information, this advising as to large and expensively built houses. I have, however, I am sorry to say, too much experience as to the absolute necessity of attention and alteration being required in matters of drains and ventilation, even in the most recently constructed and costly mansions. Apparatus and means to warm and to confine the air have been applied, but not the means to produce unceasing change—that is, true ventilation.

It is almost impossible to get persons to consider air as they consider a solid, or as they consider a fluid—that is, that two particles of air cannot be in one place at the same time; if a cube just fits a box, to put in a second cube the first must be removed; or, if a tank is full of water and more is poured in, there will be overflow equivalent to the volume added. The air in any house or room, like the cube in the box, or the water in the tank, just fills both house and room, and air only differs from the solid cube, and tank of water, in being invisible, intangible, and elastic, and therefore it is more easily moved; but every cubic foot of fresh air, or indeed air of any sort, when passed into any ordinary house or room, displaces—that is, pushes out—a corresponding cubic foot, and so on for any lesser or greater volume. If a fire is to burn in a room air must pass up the chimney, and an equivalent volume must come in, and will come, in spite of all the

choking and blocking of draughts from chinks at doors and windows, or air will come down the chimney in puffs, and so cause smoke. There should, therefore, be to all rooms special means for ventilation, to admit fresh air, equivalent to the sectional area of the flue at least; but, as in the flue, the fire quickens the up-current, the means for admission should be greater—say, double this area; this will prevent those keen, cold, cutting draughts from window-chinks and door-bottoms which cut like a knife and chill like ice. Let the required air come in, and, in winter, be warmed, if practicable, so that draughts cannot be felt—that is, the supply to the rooms should be from hall, corridor, or staircase, in thin, slit-like openings, not in square blocks, and then the painful and injurious draughts will cease. There is no other power in a room to cause air to rush in but the fire, the temperature generated, and the fire-place flue, which is an extractor. Large and costly houses, warmed by expensive apparatus, are, as stated, frequently left without adequate means for ventilation. External air and external temperature are so dreaded that change of air is prevented. In the old rude houses of former times, with wood fires of large size, flues up which the family chariot might have been hoisted, and with large barn-like doors which did not fit, ventilation was abundant.

These remarks and suggestions are general—so general, indeed, that they may draw forth the remark that "they are useless." I however hope that thoughtful people may learn something practically useful from them.

As to breaking drains open on the outside of the house-walls, so as to stop all direct flue connection with the sewer, it may be said, "But the foul sewer gases will come out." This will be so; but, as there is foul gas to come out, will you let it go freely to the open air, outside your house; or, continue to let it pass by drain and sink-pipe and all other inside chinks, from rat-holes to the basement, and so up and through the whole house? But, remember, this foul gas may be conducted by a pipe (not less than three inches diameter) to any point you direct outside the house, even above the roof, where there will be unceasing dilution and dispersion; and the dilution will be as the cube of the space. Any builder ought to be able to do the work indicated.

Bedrooms may have open windows during the day at least, and means at or near the ceiling to ventilate or change the air from the staircase, corridor or passages, at all times. Fireplaces and flues in bedrooms ought never to be closed up, winter or summer.

When sickness unfortunately occurs, mothers and nurses frequently act very foolishly and injuriously by closing all means for external air to enter either doors or windows, and by keeping curtains drawn round the bed of the sick. If medical men will pardon my impertinence, I venture to say that they do not in all cases act boldly. They know that a warm and stuffy atmosphere is liable to be injurious, but they do not always insist with all possible energy, to have the evil removed—that is, to have full and free ventilation.

No doubt there are cases where warm air is to the patient life, but even in such cases the warm air should be pure, and to ensure this ventilation is necessary; there should be through such sick room an unceasing flow of unpolluted warm air, producing change, and removing the emanations from lungs and skin. Many forms of disease—almost every form of zymotic disease—will, however, bear a deal of starving as regards air temperature, if the patient is warmly covered up and protected from perceptible impinging draughts; the windows of a sick room may be open in fever cases, night and day, and, under due care, even in the depth of winter. I say this advisedly, as the result of experience.

There are large books on ventilation, and many patents have been taken out for warming and ventilating. Royal Commissions have been appointed, and have expended thousands of pounds on experiments, and have reported on modes of warming and ventilating. Prisons, churches, palaces, hospitals, and public buildings are warmed and ventilated by some of these means, as are also many private houses; but the vast mass of the inhabited houses of the British Islands have no ordered and arranged mode of ventilation, nor ever will have; and from want of knowledge and lack of thought, persons injure the health of their families and their own, by confining foul air, or allowing it to be confined, within their dwellings; the unfortunate inhabitants breathing and re-breathing it. The costly works on ventilation referred to are not consulted, and if they were studied ever so much, many of the appliances recommended would be found to be, for cottages, impracticable. Writers on the subject have considered that ventilation must be scientific, complicated, and costly; when, practically, the mode of ventilation cannot be too simple. Air is never so fresh as when it comes into a house or room direct; there is some deleterious property in flues which takes the life out of the air passed through. This has been found to be the case in flue-ventilated hospitals; and, after the experiment has caused the loss of many lives, flue-ventilation has been abandoned and open windows resorted to.

These suggestions as to ventilation are for the consideration of the multitude who have no special books to study, no warming-apparatus, nor ever will have. To all such I say—the dweller in the smallest house or cottage, for instance—ventilate your drain if there is one, and ventilate your staircase by openings at the roof or skylight, or at some upper window. Open, and preserve open, all chamber flues; secure means of changing the air in bed-rooms; and, if sickness occurs, remember, that fresh air (change of air) is absolutely more required in sickness than in robust health; remember, also, that delicate persons, adults or children, require well-ventilated rooms both by day and by night, but more especially through long winter nights. Health must, however, be a matter of personal care; and homes can only be preserved healthy by unceasing personal care. The most perfect apparatus may be of no effect through mal-arrangement or through misuse, as also through

neglect. It may be said, "All this is the work of the architect or builder;" and the tenant may say, "You surely do not expect me to do such work!" I can only reply, that architects and builders, as a rule, do not make sufficient provision for ventilation, but that, by perfection of workmanship, in West-end London houses, they do make provision for preventing ventilation. London house-drains are not, as a rule, ventilated, but, fortunately for Londoners, the sewers are ventilated; in the country, however, and in a vast number of provincial towns, neither house-drains nor street-sewers are sufficiently ventilated, and there is an unmeaning, false-reasoning, and obstinate rejection and resistance to main-sewer ventilation at the street surfaces. The mode is, no doubt, rude and may be improved, but it is a thousand times better than none.

Better, indeed, be without sewers and drains than have them connected direct with the house, without ventilation and dilution of sewage gases. The tenant cannot certainly ventilate the street sewers, but he can move the local governing body to do this, and he can ventilate his house-drain, and he can also secure house and room ventilation by opening windows as suggested. The Chinese are said to have a proverb which runs as follows:—"Fools and beggars only suffer from cold. Fools because they have not sense to wear sufficient clothing; beggars because they are too poor to procure clothing." The effects of our English climate may in a very great degree be modified by warm clothing.

P.S.—Prisons are in England, at this moment, the most healthy residences, as they are admirably warmed, ventilated, and supplied with water. Those who have read recently-published hospital literature will know that in many cases, both in England, France, and other countries, flue-ventilation has been abandoned, on account of excessive mortality in the wards, and simpler modes of letting in fresh air by windows and other arrangements have been adopted. Medical men should be supposed to know this fact.

In Japan the houses are slightly built and open; and there are screens used to divide spaces to serve as separate rooms. Mr. J. F. Campbell, in his book of travels, "My Circular Notes," records, the country covered with snow, the temperature 27° outside, 31° inside, or, 36° outside, 39° inside, showing that the outside temperature and that of the inside, where he was sleeping, did not vary more than three or four degrees of temperature, warmth and comfort having been obtained by light-quilted bed-coverings, the screens preventing drafts.

WHOLESOME HOUSES.

Second Letter to "THE TIMES," February 6th, 1873.

To the Editor, SIR,—I think the popular interpretation given to my letter to *The Times* (6th January) a little wide of my meaning; and with your leave and forbearance I will attempt to explain myself more clearly, for the instruction of those who say that they have suffered by following (I say) their own ideas of my suggestions, rather than the suggestions as intended to be embodied in my letter. It has, apparently, been widely inferred that I advocate open windows in all weathers, with a use of shawls and top-coats indoors, as the case may be, for those who feel cold. The word "open" has, however, been read as if it meant "wide open." A few days after my letter appeared, I called upon a lady, who had resided many years in India, and found her sitting with a French window wide open, looking anything but comfortable, but who welcomed me with a faint smile, saying, "See, Mr. Rawlinson, I am following your advice." Another lady writes from the north of Scotland to a friend, that "she is suffering from sitting with open windows, *à la* Rawlinson." A lady friend also writes to me from Liverpool, "Must I understand from your letter in *The Times*, that you have ceased to warm your once comfortable house, and sit in your top-coat with the window open? as, if so, I do not agree with you." Then I see that even *Punch* embodies the open window and warm clothing notion in some admirably-drawn woodcuts; I must therefore have written obscurely, and my sentences have evidently not conveyed the information I intended should be given.

More forcibly to illustrate my meaning, I will, if you will allow me, describe my practice; and as the *Standard* in a leader wondered "what sort of a house Mr. Rawlinson lived in," with your leave I will tell him. My dining-room and drawing room each contain about 5,500 cubic feet of space. The doors are 9 feet high by 4 feet wide. My bed-room and dressing-room contain about 6,700 cubic feet of space. These rooms are warmed by ordinary open fire-places; the basement, entrance-hall, and staircase are occasionally, and only occasionally, say 20 to 30 days throughout the winter, warmed by hot-water apparatus (coils of iron piping). It will be noted that the dining and drawing-room doors are unusually large; this is an advantage in room ventilation, as the swing of so large a door moves a surface area of 36 square feet and the cube of the entire room; and sitting-room doors are, of course, frequently opened and shut during the day, so that there is both motion and change. Lofty doors are more common on the Continent than in England; their

advantage is, that they change the air near the ceiling much more freely than doors of 6 feet 6 inches or 7 feet high. Now, as to home practice. I have fixed means for ventilation in the basement at eight points beneath the floors, in each case the inlet being through charcoal strainers; the subsoil is covered with concrete, the sleeper blocks are vitreous earthenware, the sleeper joists are sound old ship timber, and there is a vitreous damp-proof course above the footings in all the walls. Drains are external and are ventilated; sink-pipes and waste-water pipes discharge, open, over drain heads; cloak-room and water-closets have fixed means for ventilation. Near the ceilings, and opposite my bedroom door, there is a landing window, and on the inside of my bedroom door there is a chain, upon which the door is opened—say 1½ inches wide, when the room is occupied, and the window on the landing opposite is regulated according to the weather. In warmer weather the window in the dressing-room is also opened some 3 inches, top and bottom, so that for my bedroom I have an area of inlet at all times for air round the door equal to 15 feet by 1 inch wide, *plus* the dressing-room window in warmer weather. The bed has, at the head, a narrow single curtain on each side, but no top or valance. Now for two persons I have 6,700 cubic feet of space to sleep in, and I find it absolutely necessary for my health's sake to have the means of change of air described. I do not avoid artificial warming and bedroom fires for economy's sake, but for health's sake; hence the hot-water apparatus is used only in the coldest weather, and then always with ventilation at the staircase ceiling, which is never closed, and frequently by the staircase window also, which is partly opened. A fire in my bedroom is very seldom lighted, as I find by experience that a low night temperature in a bedroom better fits me to endure a low external temperature through the day. I clothe warmly, avoid draughts, and strive to keep my sitting-room at or about 65 degrees Fahrenheit; and if, during frost, I feel "roasted on one side and frozen on the other side," I sit in a top-coat, but not with an open window. I stated, in my letter of the 6th ultimo, "that health must be a matter of personal care, and that homes can only be preserved healthy by unceasing personal care, and that the most perfect apparatus may be of no effect through mal-arrangement, or through misuse—as, also, through neglect." I also said that architects and builders, as a rule, do not make provision for ventilation. The architects are angry at such imputation; but I have no need to indicate many special examples, as, unfortunately, they are too numerous all over the West-end of London, as well as in other places. Let me, however, name one or two very prominent specimens of neglect. Take the Committee-rooms of the Houses of Parliament.* They are without the means of convenience and comfort which such rooms ought to have. There are no Members' retiring-rooms, no means for ventilation, but the most abominably-

* There are now after-thought make-shift means for ventilation to some of the Committee-rooms.

contrived windows; no adequate means even for suspending diagrams which are required to be used in Committee inquiries. The main-sewer is parallel with the Thames, and down the centre of the building beneath, but within the area enclosed by the basement walls, so that all the sewage of the place is accumulated within the building. Take Buckingham Palace, as another example, and at this moment the State Ball-room is being cut up, at great cost, to obtain better means for ventilation, although it is not many years old.

Houses of the better class have two purposes to serve—namely, that of providing means of warmth, comfort, and health for the family, and of occasionally accommodating a party, a number—that is, an assembly, in comfort. This latter purpose is rarely, if ever, provided for. If I were building a new house for myself, I would continue all door-spaces from the floor to the ceiling, place the door lintel in its proper place, and in the open space above form reefing louvres from the doorhead architraves up to the ceiling. With company in the room, and fully lighted, all the space above the door could then be opened, and this would prevent any undue accumulation of heat at the ceiling, and ventilate the room with the door shut. Gas is now generally used, and this consumes more oxygen, gives off more heat, and also more injurious vapours than the lamps and wax candles of olden times. Architects and builders, as a rule, do not provide flues or any other special means to remove these excessive accumulations of heat and deleterious products of combustion from the top of the room, as may most easily and even cheaply be done, as indicated, and if provided for in the original construction. An atmospheric temperature of deleterious compounds up to 120 Fahrenheit at the ceiling over a dinner table or in a drawing-room, full of company, is usual rather than exceptional; which it ought to be, and might very easily be, if proper means for escape to this excessively heated and vitiated air had been or were provided. But now here comes the rub—flues, or openings, capable of letting out heated air when it is generated, will also let in cold air if not specially regulated; and as this regulation requires personal intelligence and care, which it very rarely gets—probably never, but from some inventor or adapter—architects shrink from meddling with the matter, and rest contented to leave the world no wiser than they found it. Ventilation has, of course, been written upon by many authors, and has been practised with some success, and as public attention—but better still, individual attention—is turned to the subject, those who practise house-ventilation most successfully may make their fortunes. As to hospital ventilation, there has been plenty of this, but probably with as much of mischief as of good. Hospital wards require vast volumes of air as fresh, and as pure, and as direct to the room as it can be obtained. Those who desire to learn all about artificial modes of ventilating hospitals, and the consequences resulting to the sick from some of these modes, may find it fully written in the reports of the medical officer to the Privy Council.

Gaols are about the best modern examples of artificial warming and ventilation. They are, in fact, at present the only residences I know of which a man can inhabit, where sewerage, drainage, water-supply, warming and ventilation are at the highest point of perfection. They are incomparably better provided for in these means of health and comfort than many palaces, noblemen's mansions, London clubs, London West-end houses, or than town or country cottages. But there are no valid reasons why every dwelling-place, from a palace to a cottage, should not be as comfortable and as wholesome as a prison. Similar knowledge and intelligence in design and execution, with similar intelligence and care in management, would produce similar results in honest men's houses. But far too often the last thing a strong, healthy, active, business man thinks about are means to continue and secure health. It is only when the constitution has been undermined, probably by foul air, that some remedy is eagerly sought after; and then foreign travel for change of air is recommended—"change of air" at home, sweeter, fresher air, shorter hours, a better regulated diet, and warmer clothing would most probably have obviated much of this misery, disappointment, and premature death. When a man goes abroad in ill health he takes his disease with him, but he leaves home comforts, imperfect as they may have been, to experience far worse foreign discomforts; and, in sanitary arrangements, he must put up with and suffer from some of an indescribable but frightful kind.

I will attempt to describe an English residence—not an imaginary case, but a type, I am sorry to say, of many large houses in existence over the length and breadth of Great Britain. It is about 20 years since this case came beneath my notice. In one of the midland counties of England stood a mansion in its own park, with charming landscape views around; the house was roomy, substantial, and, in some respects, might have been termed ornamental. The reception-rooms were handsomely furnished, and the owner, being wealthy, and a man of taste, had a fine collection of pictures and drawings, with bronzes and other articles of *vertu*. The family was young and numerous, and, previous to the occupation of this house, had been remarkably healthy. Before twelve months' occupation had passed sickness commenced, both among the servants and the youngest children. It set in with lassitude, headaches, low fevers, and liability to colds and sore throat. Some of the servants had to leave; then the youngest child died, and after this a second, the elder girls being weak, languid, and sickly; the mother began to break down with watching and weariness, and then the eldest daughter died. The sons and father, being more out of doors, did not suffer in anything like the same degree; but, seeing his home gradually made desolate, and the health of his wife and remaining daughters sinking; under advice he left the place and went southwards to a warmer and milder climate. The house and estate, after a time, were sold, and were again occupied, the new residents commencing a similar course of sickness, ending also in premature deaths. The remaining portion of

this family also terminated their occupation by leaving the place in despair. The house was again sold "a great bargain;" but the purchaser, knowing something of the history of the previous occupants, and hearing it said that "the place was unhealthy," had the cellar floors broken up and examined. The entire basement of the house was then found to be traversed by large sewers and drains, commencing in cesspits and ending in cesspools. The subsoil was, like the sewers and drains, porous; closets and sinks having passed solids and fluids into these cesspits, sewers, and drains, to accumulate, to stagnate, to ferment, and to generate and give off foul gases, external means for ventilation not having been provided, so that the foul gases permeated through chinks, cracks, and rat-holes into and through the house. In the yard outside, as also in the scullery inside, there were wells and pumps, the water being, however, cool, bright, and sparkling. Large cisterns of lead caught from the roofs rain-water, to be used for washing; but, as it made stronger tea than the pump-water, it was frequently used for this purpose. Chemical analysis showed that the well-water, notwithstanding the tempting appearance, was sewage-tainted, through the subsoil, so as to be poisonous; and the large open lead cisterns were observed to be "bright as silver" between "wind and water," and analysis found that this gave an impregnation of lead to this soft water. The causes of past sickness, premature deaths, and untellable family misery were fully revealed, —the entire basement of this beautifully-situated country mansion proving on examination to have been one vast cesspit of corrupt and corrupting matter, tainting air and water alike. The cesspits and cesspools were emptied and filled in with earth and quick-lime, the large sewers and foul drains, with the foul subsoil, were removed, and the entire area covered with quick-lime concrete. New drains were laid, which were both water and air tight, and these were fully ventilated, and sink pipes were cut off from the drains. A supply of water from a spring at a distance was brought in, and the house then, as a dwelling, became as wholesome to live in as it was charming to look at. The cost to remedy the basement, the sewers, and the drains was about £1,100; the cost of the new water supply, with fire apparatus and fittings, about £1,500—total, £2,600. The original cost of the house to build might have been about £20,000. House and estate sold for £70,000, having upwards of 600 acres of land.

I give this case in full, which is not imaginary, as a warning; and the cost of renovation for consideration. Old houses, nor, indeed, new houses, if in such a mess as described, cannot be pulled to pieces and be made safe at a small cost; but to do such necessary work in the first instance, as a part of the original plan and construction, would not cost one-fourth of the sum named. All country houses (mansions) are not so bad as the one described; but, having inspected many houses in all parts of England during the last quarter of a century, I feel bound to say that I have never found one with unobjectionable and safe drainage. Cesspools within

houses came in with water-closets about the beginning of this century. They have made many an old county family childless and desolate.

I have been accused of not being practical, because, I suppose, I did not, in a letter, discourse learnedly and technically on every point of house-construction, warming, and ventilation, neither did I recommend anybody's patent; but I did in a degree censure some architects and some builders. Well, let me end now with repeating a few practical remarks:—

For New Houses.—Before building, select a dry subsoil, and cover the entire basement with concrete.

Use a damp-proof course on the footings to all walls; use vitreous sleeper-blocks for basement floors; ventilate the space beneath the basement through charcoal, and cover the concrete beneath the boarded basement floors with charcoal also.

Place all sinks and closets against external walls, and let all drains commence from external walls; and if a drain must cross a basement, see that it is of indestructible materials, and is both water-tight and air-tight.

Ventilate all drains fully external to the house; and if there must be a cesspool, place it as far from the house as possible; do not let any drain act from it as a flue, but break the connection, and do not let it have a close top, but abundantly ventilate it.

Do not let sink pipes or overflow pipes go direct into drains, but empty outside over a prepared drain and trap.

Ventilate the cloak-room, all the water-closets, and the staircase at the highest possible points in the house.

Arrange to ventilate all bedrooms at or near the ceiling by openings to the stairs, landings, or passages.

Arrange flues in floors, ceilings, and walls to remove the products of combustion from gas, and see that these have proper valves; but, better still, let every door-space be carried from floor to ceiling, and arrange to open or to close the space over the doors in sections by louvres, as may be required.

Warm the basements, entrance-hall corridors, and staircases with hot-water apparatus, taking care, however, to feed the flues with fresh air; and see that there are means for ventilation as well as for warming.

See also that your warming apparatus and flues are not likely to set your house on fire, or to make some rooms unbearable by the heat from the flues.

Tell your architect to arrange water-cisterns, water-pipes, and roof-gutters in such manner that overflows or burstings, if such ever occur, shall not inevitably flood and destroy the best ceilings, the best carpets, and the best furniture in the house.

Arrange that a gas-light or lamp may be placed during frost so as to prevent the water-pipes being frozen. This is not impracticable; but, if a part of the original plan, may be cheap and easy.

For Existing Houses.—If the basement is stuffy, have the drains examined and ventilate the rooms (cellars). Use a Sherringham;

ventilate the cloak-room through the wall, at the ceiling; ventilate water-closets, house-maids' closets, and also ventilate the head of the staircase, as previously described. Water-closets should have fixed means for ventilation through the wall, at the ceiling (independent of windows), equal to a slit 12 inches long and 1 inch wide.

Bedrooms may be permanently ventilated by one or two openings—say 12 inches by 9 inches, through the partition wall, from the corridor, landing, or staircase, having a plate of perforated zinc on each side, which will answer the required purpose of checking the draught.

The chimney-tops of London houses show in grim array various forms of pipes, cowls, and turncaps, and it will be news to many persons to be told that these hideous contrivances are not necessary. The late Mr. Billings must have the credit of having applied the best remedy for flue-tops ever used. In place of contracting the flue outside the chimney-top by a pipe, he has placed this down the flue, from the top, inside, and finished with a terra-cotta cap and mid-feather to divide flue-top from flue-top, the terra-cotta top or cap having a slope at an angle of 45 degrees. Look at Marlborough House. There is not a single external pipe or cowl on any chimney-stack or flue to be seen. Some of the War Office chimneys, some of the Admiralty chimneys, the Treasury buildings, Somerset House, and other public offices and many private houses have also been so treated—my own house, for instance; and in all cases the draught of the flue is improved. But Mr. Billings insisted on treating the bottom of the flue as well as the top. His principle was to reduce the ordinary flue of 14 inches by 9 inches to a circle of 9 inches or 6 inches, as he considered the room might require. I have not a smoky room in my house, and I have neither pot, pipe, nor cowl on any flue, but Billings's tops, as described. My neighbours have pipes and cowls, and smoky rooms as well, the houses being on a plan similar to mine. With a 6-inch opening into and out of a flue 14 inches by 9 inches, the space between the top of the flue and the bottom acts like a cushion or spiral spring, and so admits of the upward current of smoke flowing out more evenly and rapidly than with the full width of the flue; which, when open, admits a down or counter draught, the tendency of which is to chill and stop or retard the regularity of the upward flow of smoke.

The varieties of fire-grates and stoves, closed and open, may almost be termed infinite. Modes of warming and of ventilating are also numerous, from the ancient Roman tepidarium downwards. Houses, if built fire-proof, might have the old Roman hollow brick flues through floors and walls, giving an equable temperature through the winter at a comparatively cheap cost; but we want modern houses for summer use as well as those of winter, and vitreous fire-proof surfaces would be chilly and damp in June, July, and August. It may be very well to *dream* of dwelling in marble halls, but they are awfully miserable residences for people *wide-awake*.

EXCEPTIONAL RAINFALL.

Letter to "The Times," November 20th, 1872.

To the Editor, Sir,—Tables of figures are seldom read by the public, and meteorological returns are necessarily tabulated. I propose, however, to state a few facts obtained from experience and the consultation of many tables and returns from places wide apart relative to the weather. For some purposes "averages" are taken, and these certainly show that temperature, fall of rain, direction of wind, and atmospheric moisture, vary considerably, not only over the surface of the earth, as might be expected, but also over defined areas and districts. Averages, however, only tell part of the story, and must be thoroughly understood to prevent misleading conclusions. We can, nevertheless, do little without averages. The late Luke Howard, by his observations on meteorology and the climate of London, made in the metropolis and various places about it for some 40 years of the beginning of this century, compiled and embodied facts from which inferences may be drawn applicable to the science generally.

The average annual fall of rain in and around London from New Year's Day to New Year's Day is about 25 inches; but in the series averaged there are wet years and dry years. Having examined, not only these metropolitan rainfall tables, but also those for many other places in Great Britain, Europe, India, and Australia, one leading fact stands manifest—namely, that dry years are to wet years, in their depth of rain, about as one to two; so that the average for a district being given, the probable driest and probable wettest years may be ascertained; and it is a knowledge of these excesses which is most useful both to the civil engineer and to the agriculturist. The average fall of rain in the Thames valley, for instance, may be taken as 30 inches. To find the driest year, deduct one-third, or 10 inches, and there will stand 20 inches. To find the wettest year, add one-third, and the result will be 40 inches. It is not pretended that these proportions are exact for all places, but the rule is applicable to very many places.

Old and popular proverbs about the weather are not in all cases to be relied upon. April, for instance, in the Metropolitan district, is the driest month, and November the wettest; spring being the driest quarter, and autumn the wettest. Evaporation is, of course, greatest in summer and least in winter.

These facts relative to wet and dry years, barely stated, only set forth part of the story. Springs, streams, lakes, and rivers are fed by dew and rain. The volumes of rain falling in any year, as recorded, have been measured through the instrumentality of a rain gauge; but this is by no means the depth of rain which flows over and off the surface, as heavy showers may and do fall on dried and heated surfaces in such proportions and at such intervals as to give no flow down streams or rivers, the entire fall being re-evaporated, so that the whole country is parched and burnt-up. Then, with respect to the wet years; the fall of rain may be concentrated into a few months, when the earth becomes saturated, and water flows off water, causing inundating floods. The varying volumes of water falling in rain and flowing from the ground may be best studied in the vertical rise of rivers from the extreme dry weather states to their extreme flooded states, and this is something terrible in effect—as witness the devastating floods of this autumn in various parts—Italy for instance. Channels which have been absolutely dry for months and even for years are rapidly converted into roaring and devastating torrents. But this is no new phenomenon, it is only exceptional, recurring at intervals, and in accordance with laws which ought to be more generally understood.

Rivers in Great Britain rise in floods from 20 to 30 feet vertical in their upper and mid portions. The Eden at Carlisle and the Ouse at York have both risen as much as 23 feet vertical from summer level. Lakes, if of considerable area, tend to equalize this rise. The Cumberland and Irish lakes rise, however, some 12 feet vertical in floods. The Great North American Lakes are so vast in area as not to be similarly affected.

Rivers in Africa and in Australia are raised, in floods, 70 feet and even up to 120 feet vertical, flooding vast areas of country. From the mountain ranges of India sudden floods of water come down in a vertical bore several feet in height, roaring and tearing up all obstructions. The amount of solid materials excavated and moved along by such river floods is incalculable. Rocks are rifted, and the largest and heaviest blocks of stone are flooded down as if they had no more gravity than cork. Old river beds are abandoned and new channels washed out, so that in some places—Spain for instance—a bridge is to be seen where there is now no river, and over the actual river there is no bridge. In Australia bridges are submerged, so that "Take notice, when this bridge is over head this road is impassable"—a warning said to have been put up in Wales, but it was probably Ireland—must be necessary.*

The unceasing action of precipitated atmospheric water is to disintegrate the solids of the dry land and move them to the ocean; and probably as much solid matter is moved imperceptibly as violently. About four-fifths of the crust of our globe is limestone, or contains lime. Rain-water is almost absolutely pure water, and is a powerful

* In Australia elevated fords are constructed which serve as bridges during ordinary periods, but which are submerged during floods. The district cannot afford to construct bridges to rise above extreme floods.

solvent of lime, so that every gallon of rain falling on limestone strata dissolves its portion of lime, as salt is dissolved, and removes this to the ocean. The Thames may be taken as an instance. The water of this river, flowing from and over oolitic limestones and chalk, dissolves and takes up about 16 grains of bicarbonate of lime in each gallon, and this amounts to about one ton for each million gallons. London receives for its water supply about 100 millions of gallons of lime-impregnated water per day, in which there is 100 tons of this bicarbonate of lime, or 365 tons of solid rock dissolved per annum in the water used for domestic purposes in this one city. Rivers therefore, act as excavators, both chymically and mechanically, wasting mountain ranges, scooping out ravines and valleys, and washing down the solids to form deltas and new strata below the waves of the ocean; the mechanical grinding power of the unceasing shore-waves being probably the greatest.

Rivers, in flood, excavate and move solids from steep gradients to silt and lift the plains. Where this process is made available by man it is termed "warping," and is useful; but where the process is neglected, and river beds are allowed to silt and rise above the inhabited plains, retributive destruction follows.

It is the purport of these remarks to direct attention to this fact. Every country bears its special character upon its face if one can only learn to read it. Mountain ranges are Nature's distilleries. Water is the great integrator, excavator, and carrier, both in calm and in flood. As previously explained, the heat to evaporate is from the sun, the water to be evaporated is that of the ocean, the atmosphere is the receiving and moving medium, and the mountains are the condensers, rivers being the conduits to return the fluid and solids back to the parent ocean. In Nature there is alternate storm and calm, drought and flood—irregular as to days, months, and years, but absolutely regular over cycles—not, however, in all cases to be defined. Man cannot alter nor stop the phenomena; but by a study of the past he may prepare for the future, and so save his works from violent outbreaks, which are as much in the order of Nature as the quiescent periods of years of ordinary procedure through which he may have been idling. Embankments and bridges will be destroyed, and valleys and towns will be flooded, if men forget that Nature can occasionally frown as well as smile.

EXCEPTIONAL RAINFALL IN CUMBERLAND.

Extract from "The Times," January 20th, 1873.

Mr. Isaac Fletcher, M.P. for Cockermouth, who has for several years kept rain gauges at various stations among the Cumberland mountains, has published in the *Carlisle Journal* the records of each month during the year 1872. His gauge at Seathwaite, at the head of Borrowdale, has been established for nearly 30 years, and the returns of the past year indicate that in the heart of the

lake district the rainfall of 1872 has not been exceeded in any year during that period. The following figures show the total rainfall at each station during the whole year, the numbers in parentheses indicating the height in feet above the mean level of the sea:—Scawfell Pike (3,200), 90·75 in.; Great End (2,982), 91·40 in.; Brant Rigg (695), 118·68 in.; Esk Hause (2,550), 121·27 in.; Wastdale Head (247), 131·30 in.; Sprinkling Tarn (1,986), 170·33 in.; Styhead Tarn (1,472), 177·04 in.; Seathwaite (422), 186·25 in.; Taylor's Gill (1,070), 224·73 in.; the Stye (1,077), 224·73 in. The number of wet days at Seathwaite during the year (the only place where this record of wet days seems to have been made) was 228. In January there were 27 wet days, and the same number in September. In July (12) and April (13) there were the fewest wet days. With regard to the Seathwaite return Mr. Fletcher remarks that the quantity (186·25 in.) is taken from the 4-in. gauge, read once a month, and which is precisely similar to the rest of the mountain gauges; but the old gauge, which has been there and uninterruptedly used daily since the year 1844, gives a quantity somewhat less—namely, 181·93. If the latter quantity be accepted as the correct one, it is exceeded slightly by the year 1861, when 182·47 in. were measured. The difference, however, is so slight, that the two years may be assumed to stand on a par. The next greatest record of rain at Seathwaite was for the year 1866. The gauges at the Stye and Taylor's Gill were not established in 1861, so that a comparison cannot be instituted; but Mr. Fletcher remarks:—"The amount registered on the Stye—nearly 244 in.—is marvellous, and is greatly in excess of any previous record. In 1866 224·56 in. were recorded. So far as has yet been ascertained, the Stye is the wettest spot in Europe, and, except in tropical countries, the quantities I have quoted represent the two greatest annual falls of rain that have ever been recorded. The fall in January, 1872, is, however, more wonderful still, viz.—50·05 in., about double the average annual fall in Carlisle. January, 1873, bids fair to rival its predecessor."

EXCEPTIONAL WEATHER.

Letter to "The Times," November 1st, 1872.

To the Editor, Sir,—We are having just now what may be termed "exceptional weather," continued heavy falls of rain causing deluging floods of a very destructive character. Many persons who do not understand what is the origin of meteorological phenomena infer excess of rain from very inadequate causes—as extensive land-draining, clearing of forests by the cutting down of timber, cultivation, &c. Works and operations of this character do modify local climates during ordinary seasons and periods. Draining land, by removing stagnant surface and subsoil-water, raises the temperature in proportion as excess of evaporation is prevented. Cutting down large forests may have a complicated effect, as the thick forest prevents subsoil and surface evaporation by shutting off the rays of the sun, but growing timber is a very powerful evaporator. For every pound of woody fibre formed several hundreds of pounds of water must be evaporated; every blade of grass, while growing, is, however, also a water evaporator. Water is, therefore, a necessary element to growing vegetation, the most minute or the most gigantic; without soil there is no protecting vegetation. Make the growth of permanent grasses impossible, as beneath the copper smoke of the Vale of Swansea, and all vegetable soil vanishes. The wide arid deserts of the earth become and remain deserts for lack of atmospheric moisture. Meteorology cannot be explained briefly; an enumeration of the leading elements may, however, be short and simple. The sun furnishes the heat, the salt water the ocean, and the atmosphere the laboratory. If the heat of the sun annually varies (as no doubt it does within certain limits), evaporation from the ocean must vary, and condensation from the atmosphere must also vary. It may be stated broadly, that fresh water, upon the surface or beneath the surface, over the entire globe, can have no other origin than the huge salt ocean, which covers more than three-fifths of the earth. Evaporation is unceasing from the equator to the poles; snow-capped mountains, glaciers, and icebergs are evaporating, and, during the deluging monsoon tropical falls of rain, there is excessive re-evaporation. Much of the water evaporated falls over the ocean, but the land, and especially

mountain peaks and ranges, are the gigantic condensers; here the ever-moving atmosphere precipitates any excess of moisture it may contain in snow, hail, dew or rain. Springs, lakes, and rivers, however gigantic (the Nile and the Amazon) owe their origin to the imperceptible lifting of water from the salt ocean in pure, transparent vapour. The subtle phenomenon of "latent heat" in transparent vapour need not be further touched upon, though it is this "latent heat" which is largely concerned in, not only the most simple, but also in the grandest exhibitions of nature, as hail, snow, wind, thunder, lightning, dew, and rain. Evaporation being constant, and in area as the entire surface of the earth, condensation in its most active form only occurs on portions of the area, and there not equally, but in excesses, not only in any one year, but, as in the days of Joseph, in a series of years. The water evaporated from 10,000 square miles may be precipitated in rain over 1,000 square miles, so that for the time 9,000 square miles must be without rain. One thousand, one million, or any imaginable area may be supposed, and the fall of rain may in continuance be even as one hundred, one thousand, or any other number of times in excess; it is only required to impress these leading facts on the memory. A wet year or a dry season, over the entire surface of the earth, are equally impossible. If there is more heat from the sun in one year than in another year, there must be more evaporation and more condensation; but then comparatively small areas of the earth's surface will receive the excesses. An exceptionally wet season over Europe will assuredly have, or be contrasted by, an exceptionally dry season over some other much larger area. This is so, and must be so. Excesses in nature beget excesses. The condensing and liberation of latent heat works literally with steam power to cause excess up to exhaustion. The heavy and continued fall of rain over Italy is only exceptional as regards this season, such floodings have occurred before, and will, inevitably, occur again; and these facts statesmen, engineers, agriculturists, and others ought to understand. It is a disgrace to a Government to neglect public works which would, if executed, prevent wide-spread catastrophe. It is a disgrace to an engineer to plan and construct embankments, viaducts, roads, and bridges, which the first violent flood sweeps away.

Excesses ought to have been provided for, as these excesses are part of the order of nature, and cannot be prevented. Man cannot reduce the heat of the sun, he cannot lessen the area of the ocean, neither can he direct or modify the wild turmoil of the atmosphere in the tornado or monsoon violence; but he can anticipate the worst from the past, and, with full knowledge of the power of the elements and his own weakness, prepare and work accordingly.

THE METEOROLOGY OF THE SUN.

On Monday evening, Professor Balfour Stewart, C.C.D., F.R.S., delivered a lecture to the Members of the Midland Institute, at the Masonic Hall, "On the Meteorology of the Sun, and its Connection with the Earth." He said the earth was in reality an engine, the poles of which had very little sun, but which acted as a condenser to the equator, where the sun shone, and produced a warm current of air. If, however, they turned their attention to the sun, they were inclined to think that the things which governed an engine were wanting. For a long time they might have periods of profound repose, then all at once motion started up, and a terrific current took place. In order to find out what had produced this irregularity they must go to the sun. There was no doubt the surface of the sun was composed of both solids and liquids. The fact might be taken that the surface of the sun was so hot that it possessed neither a fixed nor solid surface. Whenever a dark spot appeared on the sun's surface, there was also to be seen a bright spot. These sun-spots consisted of matter thrown up; but there was a great difference when the matter was thrown up near the rim, inasmuch as the influence of the atmosphere was visible upon it. Spots were never seen very distinctly near the centre of the sun. Under very favourable circumstances luminous volumes of fire had been seen, mounting to a height equal to hundreds of thousands of miles. The sun, like the earth, was subject to violent convulsions. For instance, while a hurricane on the earth would travel at the rate of fifty or sixty miles an hour, in the case of the sun it would travel the distance in a second. The ascending current from the earth produced an aqueous vapour, and in all probability something very similar occurred on the face of the sun, with the difference that, instead of an aqueous vapour, it was a metallic vapour. The sun-spots appeared to depend upon the position of the planets, and more especially of Mercury and Venus. Sun-spots, too, influenced the magnetism of the earth, as was instanced in the displays of aurora borealis. Meteorology was also affected by sun-spots, for the reason that it had been found that in the year when the greatest number of sun-spots were visible, a succession of cyclones invariably occurred in tropical regions. The sun and the earth appeared to work together, and therefore it was a matter of great consequence that the peculiarity of the seasons should be noted, so that the cause of anything unusual might be detected. In this way epidemics and diseases might be foretold, both in the animal and vegetable kingdom.

The lecture was illustrated by diagrams and tables in explanation of the subject.

INUNDATIONS MAY TEACH A USEFUL LESSON.

Letter to "The Times," July 1st, 1875.

To the Editor, Sir,—The terrible inundations by the Garonne may teach a useful lesson to those who will learn it, this lesson growing out of the fact that excesses in rain-floods are to be expected and should be provided for. The story of destructive river floods occurring in one part of the world or the other is ever new and is ever being told. Now, it is the south of France, from the northern slope of the Pyrenees. A short time ago it was portions of Italy, and we have recently heard of destructive rain-floods in America, in Southern Africa, in India, and in Australia, and we have not been without such cases in Great Britain, though our floods are tame and harmless compared to the inundation now under notice in France. Men who have lived through ordinarily quiet seasons believe and state that "the seasons have altered." "Agricultural drainage and cultivation have done it," "We shall never have the floods we had formerly," &c. On the other hand, planting forests or cutting down forests is said to modify climates. These things do no doubt modify fine weather climate, but in no way affect or interfere with Nature in her excesses, as all the labour of all the men who ever lived, or ever will live, never did nor ever can add or diminish one degree of heat to or from the sun; consequently, the laws of evaporation and condensation go on unaffected by agriculture, or forest-denuding, or forest-planting. The heat of the sun, the area of the ocean, and the volume of the atmosphere, cannot be regulated, and it is upon these that weather depends; the heat from the sun may vary according to the great and subtle law of pulsation pervading all nature; which, like the swing of the pendulum, is regular in its irregularity; if, therefore, there are such pulsations or tides in the heat from the sun the meteorology of the earth must correspond sympathetically with such changes, and times of greatest heat will be times of most evaporation and of heaviest rainfall. As man cannot control the elements, what can he do? He can strive to understand the laws and actions of nature, and as much as possible anticipate the probable excesses, and so avoid the effects. Nature is neither secret nor hypocritical; she works, in meteorology at all events, openly and above board. Floods of former periods engrave their history down mountain

slopes and through alluvial valleys, but young men take no note of such evidences. Hence houses, bridges, and towns are thoughtlessly placed in the way of the first "excessive" flood which happens; this—"who could have thought it"—excess having been plainly written by former excesses in the district.

Mountain streams both raise their beds and deepen them; as, during ordinary seasons the upper floods loosen and bring down gravel, sand, and silt, to leave much of it where the slopes allow of a slackened current. Again, weirs, bridges, and other works on rivers interrupt the ordinary flow and induce deposit, which lifts the bed of such rivers above their former levels, so that a sudden excess from a combination of natural causes, as in the South of France—excess of snow to be melted, a rapid rise in temperature, with heavy rainfall—produces a flood which is overwhelming. The mistake is in thinking that such a flood is unprecedented, as it is only unprecedented to the existing untaught generation. Ever since the Pyrenees were heaved above the ocean, devastating floods have at intervals scored their sides, and will continue this operation so long as sun, ocean, air, and mountain ridge and slope remain.

It will be only poor consolation to say to the inhabitants of the fearfully devastated district, "You should not have built your houses within the range of floods;" but will it be either cruel or unfair to say that "nature may repeat the cause of the disaster," nay, certainly will repeat it, and that if houses are rebuilt as formerly, and nothing is done by way of protection, a similar flood will be liable to cause similar destruction? With respect to our young engineers, whose bridges and viaducts have been washed down in South Africa, in India, and in Australia, the only plea available is that said to have been used by Dr. Johnson—"Sheer ignorance, Sir." The laws of excesses in nature ought to be more fully taught, and every excess of nature ought to be a lesson for the future.

CLIMATE AND HEALTH.

Letter to "The Times," December 28th, 1872.

To the Editor, Sir,—My duties having imposed upon me the consideration of health questions, not only over the extent of Great Britain, but also over large portions of the surface of the earth occupied by British residents and British troops, I may probably have something to say with respect to climates worthy of consideration. That there are climates which may be termed "wholesome" and "unwholesome" must be admitted, but the elements of this unwholesomeness, in detail, cannot be fully discussed in a letter; but some of the reasons why the verdict of the world may be reconsidered I propose to give. There are large portions of the earth's surface under the ban of being "unwholesome," this unwholesomeness consisting, for the most part, in the fatigue, exposure, and discomfort travellers have to undergo who visit and traverse these parts. This climate of ours (Great Britain) is not believed by natives born under brighter skies to be very wholesome, and during the Roman occupation the large areas of swamps and forests were then, no doubt, very unwholesome. The climate of Great Britain is at present "trying," but not unwholesome. The reason and the reply may be that 100 years of draining and cultivation have worked wonders—have, in fact, modified the climate and made it wholesome. This must not be denied. But whence come fevers and consumption, the modern scourges of the land? Sanitary science proves that there are causes in operation, social and civil, which are far more blameable than the climate; and yet more money and labour have been expended in improvements in Great Britain than on any similar area of the world's surface—in drainage, cultivation, and roads; in house-construction, in hospitals, in workhouses, and in prisons; in town sewering and in street pavements; and yet, even here, nuisances abound—such as are due to foul rivers, cesspools, tainted water, defective house-ventilation, peasants' bad cottages, cabins, &c., in England, Ireland, and Scotland—the diseases resulting from this malarrangement and neglect being, however, for the most part, set down to climate. If, therefore, neglect of well-known sanitary rules works so much mischief by causing so much "preventible disease" in Great Britain, what must be the result in climates where the elements act with greater violence and works of sanitary improvement are unknown? Examples of the fallacy of blaming climate for excess of disease may be found in a study of Army returns. British soldiers have had to endure every sort of climate under the sun, from the snows of Canada to the plains of Central India. We have Army returns, and these have been studied; and for the last fifteen years, with set special

purpose. The horrors of British hospitals and the sickness and death caused by the Crimean climate, as experienced in the years 1854-55, will not soon be forgotten by those who witnessed something of that disease, and of that dread mortality suffered by the British Army beneath an Eastern climate. The pages of *The Times* roused popular attention to the question, and tended to create that public indignation which hurled one Administration from power and substituted the late Lord Palmerston as Premier. Many of the officials engaged had the ever-ready excuse embodied in the words "inevitable" or "climate"—excesses of diseases and death they considered to be part of the official programme. *The Times* thought otherwise, and persistently, from day to day, proclaimed its thoughts in words of warning, of remonstrance, and of indignation. The finest body of men composing an army ever sent from the shores of England was fading away like snow beneath the sun. The horrors witnessed at the camp and in the hospitals were appalling. "The effects of climate" was the official reply. This letter is not to be a history of this catastrophe or of the remedy, further than to say that the Sanitary Commission sent out showed and proved on the grandest scale, that climate could not be made to bear all the blame, as the great hospitals on the Bosphorus were rapidly converted from pesthouses to being the healthiest hospitals in Europe, and the entire British Army encamped in the Crimea, by the autumn of 1855, became healthier than it had ever been in barracks at home; and this improved state of things continued to the end of the war. The "climate," however, continued to kill off both French and Russians in hospital and in the field at the established rate; means having been found effectually to prevent this destruction of the British soldier by climate. Is it to be doubted but that if similar means had been similarly applied and carried out for the French and the Russian armies, similar results might have been attained? But let us look at the effect of climate in other regions.

There are stations in the West India Islands and in British India where the climate has been reputed so deadly that despair has fallen upon regiment after regiment when ordered to them; and well might this be so, when in years of sickness a moiety of the men sent out have died within the twelve months, and many of those who survived might be described as more dead than alive. After the Crimean experience, the late Lord Herbert caused inquiry to be made both as to the state of the barracks at home and abroad, the results being embodied (buried) in despised Blue Books; but, fortunately, action has also been taken by carrying out improvements in every part of the world to which British soldiers have to go. What were the facts revealed? They may thus be briefly described. At some of the West India stations barracks and hospitals had been built by contract, the contractor finding land and buildings. The cheapest land being swamps where planters would not house negro slaves, was purchased, or appropriated, and on such sites barracks and hospitals were erected. There was, of course, no sewerage; the water for drinking was impure, and ventilation was unprovided for. The soldier had no healthful occupation or means

of relaxation and amusement, but Government did provide and license canteens, to furnish new rum. The "climate" killed men so situated, surrounded and housed, at the fearful rate described. This old story of climate, disease, and premature death is ever told afresh, and appears to the ignorant ever new. Sanitary science, however, tells another story: it does not, indeed, prove that there are not climates which are unwholesome, but it proves by results, that the main causes of disease in excess are preventible. Man must look within his dwelling for foul air rather than to the external climate; he must be more careful both of his food and of his drink, and secure pure water, and take the necessary means to obtain cheerful and moderate exercise, under proper conditions, and at proper times, so as to secure health and strength to enable him to discharge the duties society imposes upon him under the various climates of the world. An Army Sanitary Committee has now been in existence some ten or twelve years, and there are branch sanitary committees at every British station, whose duty it is to drain, scavenge, and cleanse. Local supplies of water are looked to, analyses are made of potable waters, not by ones and twos, but by hundreds, and most terrible abominations have been revealed, the water from wells being tainted to the extent of one-third urine, and this decoction has been in use. In the Presidency of Bombay, in the year 1869, upwards of 1,500 human carcases were removed from tanks and wells supplying drinking water to the inhabitants and to the troops. Fever is, as a matter of course, the scourge of man in such a climate. Cholera, we know, is ever present, and at times in terrible force. The populations of India, west and east, we now know from our inquiries and returns, are living in squalor, misery, immorality, and filth indescribable; and Europeans have not, as a rule, adopted any sanitary precautions to avoid these evils, but have added some of their own, as over-feeding and spirit-drinking—and then they blame the climate! Are we quite sure that Sierra Leone is as bad as described? This is a peninsula of about 25 miles in length, with mountains reaching to 3,000 feet elevation, around which is a marginal belt of land from one to five miles wide, on which exist, in the midst of filth and putridity, the black and coloured populations and the few Europeans. The natives bury their dead within their hut or compound—the hut in preference—and scatter every species of filth over the surface. The water is good, but the air within and around the wretched huts of the mass of the population is impure. There is an excessive mortality—all set down to the account of the climate. Sanitary regulations have never been tried on any sufficient scale; but can we doubt the result if we look to experience in other places? There is an enormous fall of rain for three months of each year, from 150 up to 300 inches, with much fog and moisture. How does the European population live during such depressing periods? Beef, bitter-beer, port-wine, rum, immorality, and tobacco-smoking may probably do as much injury as this terrible climate. Surface scavenging, at short intervals, properly carried out, would remove the true source of most of the local fever.

HEALTH AND SOLDIERING IN WEST AFRICA.

Letter to "The Times," September 22, 1873.

To the Editor, Sir,—With your permission I will offer a few practical suggestions, the result of experience, which may be useful, if enforced, both at Sierra Leone, and at the camp in South Africa.

It is not necessary to describe Sierra Leone in detail, as this has been sufficiently done for my purpose in *The Times*. The site of the town is, by past and present abuse, a mass of corruption. Burials within huts, cesspools sunk in the porous subsoil, with a surface covered with filth indescribable, a tremendous monsoon rainfall, and for several months an atmosphere like that of a vapour bath. Then there is a semi-savage negro population, untaught in any of the higher branches of sanitary science as carried out in England. Sewerage and drainage would be costly to execute, if ordered, and would be soon ruined in use; works of sewerage on the English plan need not, therefore, be contemplated. If the black town site can be changed wholly or in part, this may be done with advantage; if this cannot be done, burial within native huts should be at once stopped (orders to this end have been issued; but orders, to be effective, must be enforced). Cesspits should be abolished, and trough latrines, or some equally simple mode, be adopted, and scavengering at short intervals should be the rule.

Where rain falls at a rate of 12 or more inches in 24 hours, sewers, or subsoil-conduits for surface-floods, cannot be constructed; these surface-floods must, therefore, pass away as now. Sewers of the dimensions of railway tunnels would be filled during a Sierra Leone tornado. Conduits to remove the discharge from box-latrines may be small, just sufficient to convey waste-water and latrine-water to some outlet. If this fluid refuse cannot readily be used in irrigation, as manure (and during the monsoons and damp weather this may be impracticable or unadvisable), then it may pass by iron pipes out into the river or the sea, delivered into deep water.

Water Supply.—A pure supply of water may be drawn from the mountain slope through iron pipes, and be conveyed to stand-pipes

at convenient points within the town. This class of work should be simple, strong, and cheap. Having no plans, it is not possible to be definite in description as to works; it, however, may be sufficient to say, that English works need not be emulated. The engineer must remember in devising works, that water, under pressure, is an unsleeping enemy, and that the destructive power of such floods as flow down the Sierra Mountains is very great, so that an embankment, if placed in an improper situation—that is, on the bed of a natural stream—may be swept to destruction in a few hours. Any reservoir to store water must, therefore, be free from such contingency. If a New River sort of conduit can be formed, contouring the land from a stream never dry, this will be most advisable to adopt. The Sierra is a vast condenser of vapour at all times, and there must consequently be pure water in abundance flowing down the ravines, at the hottest and driest periods. Pure water brought in as suggested would enable the local authorities to close every tainted well in the place.

Scavengering is a question of police, a question of health and comfort, and a question of life; scavengering at short intervals should, therefore, be imperative. "A shoot" is named as discharging refuse into the sea, where it becomes a nuisance. If refuse must be so disposed of, let it be discharged into properly-prepared barges, to be towed a sufficient distance from the shore, where the refuse can be drowned, never again to reach the shore. This was done for the harbour of Balaclava during the Crimean War. There are many who will remember what this land-locked and tideless harbour was—filthy beyond description; and what it became—clean as a Cumberland lake. Scavengers' barges did the work daily. Sierra Leone may be put into a sanitary condition so as to render human life endurable, and at a cost which, if the place is worth holding, the colony can bear. Grand English works of sewering and water-supply must not, however, be attempted; but rough, ready, simple, and useful works and regulations should alone be ordered and carried out.

The Ashantee Expedition.—Let me say, at the beginning, what are my notions of an army. I conceive that each regiment should have knowledge and means within its composition to be enabled to take care of itself in a strange country, to an extent far greater than is usual. If the country produces wood, the men ought to have means, knowledge, and direction to provide temporary shelter. The Engineer Department may have a portable engine with circular saws which would cut up timber rapidly.

Well-sinking, or tube-boring, will, of course, be made available for water. The mode of drawing water should, however, be regulated, as indiscriminate drawing may foul what would, under proper regulations, be pure water. Every source of water-supply should, therefore, for the time being, have a guard over it, and appointed water-drawers. The ground in front of horse-watering troughs should be paved, or be so protected and made good as not to work into a deep puddle-hole.

Any huts sent out from England should have floors raised above the surface-soil. They should be so secured as not to be blown over, and there should be ventilation the entire length of the ridge. Patent felt covering, it must be remembered, if water-tight, is also air-tight. This was not remembered when the huts were sent to the Crimea, and fever was a consequence. Temporary shelter may be made by constructing rude open-fronted sheds—a tree-trunk, supported four or five feet from the ground, with branches sloped from it to the ground, beneath which men may obtain shelter. I have been in an Arctic forest with a body of Swedes who every night made such form of shelter, and did not take long about it. These men had also unroasted coffee-berries, but they had also a frying-pan and fire. The coffee-berries were spread in the frying-pan, held over the fire and roasted, crushed in the same pan by a flat stone. Water was then poured in and allowed to simmer, and then the coffee was drunk out of the same pan. I thought at the time that I had never in my life drunk better coffee. A Swede, with his axe, can make himself at home in the forest. A drinking-cup is made of birch-bark in a few minutes. A strip is cut from round a tree—say, six inches deep—which is like a sheet of thick paper. This is folded like a sugar-loaf. A slip of birch twig split at one end slipped in becomes a handle, and in less time than I have been describing, a useful drinking-cup has been formed, or a vessel to dip out of the river with. The *tente d'abri* has been suggested for use in South Africa. I sincerely hope, for the sake of the men, that no such tent will be adopted. I saw them in the Crimea, and wondered how medical men could ever have sanctioned them. Think of a tent which three men carry with their other *impedimenta*, which, when set up, forms a triangle, having sides of about 18 inches or 2 feet when put up entire, and beneath which the men creep! If skin-and-lung-tainted air is deadly, what must it be beneath such a contrivance? A man would have about as much fresh air if shut up in a clock-case laid flat.

Men must live to fight, and as fighting forms the practical part of a soldier's life, means to live, and to live in health, should be studied. The working knowledge and power of a regiment should be as much taught as the fighting knowledge. There should be working-drill—as trenching, well-boring, hut-building, and rough-and-ready cooking. If English soldiers are to live in South Africa they must be taught to help themselves in some practicable way.

Men who have learnt to work can teach other men to work, so that an English force which had learnt work at drill would be enabled to teach and direct the natives. The Roman legions, I am satisfied, were so taught, and so exercised their knowledge. The masonry of the Roman wall from Newcastle-upon-Tyne to Carlisle was of such a character that the natives could be made to do most of the heavy labour. In the Crimea we lost the finest army England ever sent out of the country, because it did not work, or was not directed how to work properly. Must we lose another army from the same cause?

Second Letter to "THE TIMES," October 16th, 1873.

To the Editor. SIR,—Is there no possibility of stopping this mad railway-making scheme? Those who know this African coast are, however, wondering how the material is to be landed through several miles of surf. Engineers, accustomed to railway-making and working at home, are also wondering how a 4ft. 8½ in. gauge railway is to be laid and the waggons are to be worked on the African coast, even as a temporary line. The ground to receive the sleepers must be prepared, or the rails cannot be laid; and if the sleepers are not well and truly bedded, light rails, of 24lb. to the yard, will bend like wire. (Contractors' temporary rails are, as a rule, 35lb. to the yard, and this in England, where there is time to lay them.) Let me ask any man who can reflect, what he would say to making a temporary railway in a few weeks from the coast-line of any part of Great Britain to the interior, if the materials had to be landed on a shallow lee shore in small boats, the ground to be prepared, and sleepers and rails to be laid to carry waggons and engines, then working waggons and engines on rails 24lb. to the yard? How is this to be done? As time is an element in such operations—that is, time for railway-making, which railway shall be sufficiently strong to bear locomotive engine traffic—want of time to do this will alone defeat this dreadfully ill-devised and advised railway project: unless this Ashantee business is in duration to outlast the siege of Troy. The Crimean example cannot justify a railway on the coast of Africa, where to turn over the soil and disturb the sub-soil is death, malaria being so fatal on the Gold Coast; but in the Crimea there was a quiet, protected, deep-water harbour from which to land the materials; a wholesome country to live in, and accommodation to establish steam-engine power, forges, saw-pits, circular saws, and regular workshops. The line of country intervening from Balaclava harbour to "the front" was only a few miles in length and not difficult (the steep gradient excepted); but it will be remembered that when this Crimean railway had been made and was working, a new road was also subsequently made parallel to it—showing that a railway did not supersede the necessity for a road. And so it must be in Africa. Troops cannot march on a line of railway—there must be a road, and if there is a road there is no need for a railway. If the road had been made first in the Crimea, the railway might have remained unmade. We are, I suppose, too wealthy to make war in common-sense fashion. This, Sir, is one of the signs of national decay. We had better give up such wars and abandon such colonies rather than show ourselves so contemptible; or, if this is to be our mode of procedure in the future, "Rich England" will be more a phrase of contempt than at present. There is another matter connected with this war to be noticed. Salt-beef and pork have been sent out by the Commissariat; better in such a climate feed our soldiers on turtle soup at a guinea a quart than feed them on ration salt beef and pork. Crimean experiences ought not to be wasted in this matter. Fresh meat (Australian) can be supplied in abundance.

Third Letter to "The Times," October 28th, 1873.

To the Editor. Sir,—We appear to be fairly in for this Ashantee business, railway and all, and must therefore make the best, or the worst of it, as the case may be. Will you allow me to offer a few practical suggestions for consideration?

The coast is malarious; the climate is hot, and also moist. The sick and wounded will have to be treated in the country for a time, and the mode of treatment will have much to do with their chances of recovery.

Wooden huts are being sent from England which will have patent felt roofs. There will also be tents, and probably, temporary barrack and hospital shelter provided. The wooden huts should stand clear from the ground, and not be half buried in the ground, or be banked up with earth, as in the Crimea. There should be a free play of air beneath and around the hut, and full ridge ventilation the entire length of each hut. Both tents and huts should be drained—that is, be so isolated by a trench-drain as to prevent inside flooding.

Huts, tents, and stores should be so placed as to prevent any sudden tornado of wind and rain blowing and washing them to destruction. There are storms of wind and rain in the district sudden, appalling, and destructive. Huts, tents, and stores should be out of the way of such sudden floods of water. This was not attended to in the Crimea. Huts and stores were swept down in the valley above Balaclava harbour by a sudden flood. Military regulations overcrowd both huts and tents, the result being fever. Night air is dreaded, malaria is dreaded, but the air of overcrowding is not dreaded as it ought to be. Men must breathe the air of the climate they are in for the time; closed tents and closed huts not only do not prevent this nor improve matters, but in proportion to the crowding and closeness of tent or hut, make matters worse. There is no air in the world, in any climate inhabited by human beings, so deadly as air loaded with the emanations from skin and lungs, especially diseased skin and lungs. Shelter from sun, rain, and wind should be provided, but with provision for a free change of air, night and day. A lofty barn with one end out, and each sick man having 100 square feet of floor space, would be the best hospital; any temporary structure of this sort will be next best; and where huts are used, one end may be removed and the opening be protected from wind by curtains of sail-cloth. Tents are not fit for hospital uses. The between decks of the best ship is not a fit place to crowd wounded and sick men in such a climate, as the place cannot be sufficiently ventilated; and let it be remembered, that sick and wounded men require, first and above all, fresh air, quiet, and cleanliness, with simple but wholesome diet. Physic may then indeed be "thrown to the dogs." There is no use in being told that all these rules and regulations are well known to the officers of the service, and will, of course, be put in force and be acted upon. If

this proves to be so, this letter does not occupy much time in writing, and if you, Sir, will not regret the waste in printing, I will not regret my waste of time.

But, Sir, having seen something of war, and the actual regulations in war, I can only say, that overcrowding is *not* prevented; huts and hospitals are *not* sufficiently ventilated. Tents, huts, and stores are *not* always placed out of possible flooding, and the between decks of hospital-ships (if ships ought ever to be used for hospital purposes) have been sadly and fatally overcrowded. In a climate like that of the Ashantee coast and country, free air will be the best preventive of sickness, and the best remedy for sickness. I say "free air," rather than "fresh air," advisedly; because the air of the place must be breathed, and however it is, it will be fresher and better outside of a crowded tent or hut than inside; therefore, let tents and huts be fully ventilated. Charcoal pocket-filters, and charcoal respirators, if supplied to soldiers, will, on the march, be thrown away. Mosquito nets or veils will not be used, nor any form of wash or ointment. Soldiers marching in such a climate will carry as small a load as possible. Rifle, ammunition, and kit will tax their powers, and they will drink such water as the line of march affords, or as may be served out to them. Pocket charcoal-filters do not, however, cost much, so their waste will not be very important.

THE ASHANTEE WAR.

Letter to "The Times," November 1st, 1873.

To the Editor. Sir,—The Gold Coast of Africa has had a bad name given to it, and the terror this will inspire may be the death of some of our soldiers sent on this Ashantee Expedition. To be ordered to "the white man's grave" is not a very cheering look-out; to be told to "take your coffin with you" is not hopeful. The question may therefore well be asked, and, if possible, answered, "Is the Gold Coast necessarily the white man's grave?" I think not, and for the reasons which follow.

There are several things necessary to health—a sound constitution, food, water, clothing, and protection from the weather. The climate cannot be altered, but may be made the best or the worst of. The men sent out should be of sound constitution; they should not much exceed 30 years in age. They should be clothed in woollen, have fresh meat food (not salt rations), pure water, coffee, and tea; spirits only as a medicine, quinine as a preventative, and the best protection from the weather possible under all the circumstances, always avoiding the impure air of over-crowding. Sierra Leone is not necessarily the white man's grave, as Englishmen have resided there for 30 years or more, who have returned home in health and with unimpaired constitutions. They have, however, been men who lived carefully—which means temperately; they avoided spirit-drinking.

The British soldier embarking for the Gold Coast may be reminded that his health will be cared for to the uttermost of our hygienic knowledge. There will be an able medical staff, abundance of medical stores and appliances, and a special sanitary corps to look after camping and camp arrangements. The commissariat will also be provided on a wise and liberal scale. General care is one thing, but personal care is the main thing. Each man should do his best, while implicitly obeying orders, to be careful in eating and in drinking, and on no account voluntarily to submit to over-crowding under the idea that "night air" is dangerous. Open shelter will be safer than enclosed huts or tents overcrowded. In a country of brushwood and timber, temporary shed shelter ought readily and easily to be provided. Home-sickness is frequently fatal. Men, on a first remove to a strange place, become low-

spirited, and if the climate has the reputation of being notoriously unwholesome, that climate becomes, by force of its evil reputation, unwholesome, and consequently the depression becomes fatal. Bodily action is the best preventive, and the best cure for melancholy. The troops, on being landed, should at once have working occupation, such as road-making, providing temporary shelter in the open, or some other really useful occupation, as the most fatal mistake will be to crowd the barracks or give billets in the town, and leave the men idle. The sale of spirits to the soldiers should be strictly forbidden, and the order to this effect be rigidly and severely enforced. Every gallon of spirit, when found, should be confiscated.

Let us hope that this West African campaign may serve to show that the climate is not so bad as represented. Let our soldiers consider that over the whole of British India soldier life, by hygienic care, is now prolonged and protected. In the Crimea, the climate, so fatal to our picked men in the winter of 1854-55, became, after the spring of 1855, harmless; as the entire British Army in the field was healthier than it had ever been before in barracks at home, and remained so to the end of the war. Let our men also remember that soldier life since this Crimean war has, under improved sanitary arrangements, been largely increased in value. An annual mortality of 2½ per cent. has been reduced below 1 per cent.; that is, in 1,000 of strength, 22½ deaths occurred formerly, while now, out of 1,000 of strength, the annual deaths do not exceed 7½, the improvement being due to better rules and regulations, and better care.

To conquer the African climate will give the General commanding the Expedition as much honour as conquering the Ashantee enemy.

Second Letter to "The Times," November 5th, 1873.

To the Editor. Sir,—There is a little confusion in the numbers and percentages of deaths in the British Army at the end of my letter of the 31st ult. Will you kindly allow me to correct it, and supplement the information, as it may be of use to let our soldiers know that their health is more cared for and provided for now than formerly.

After the Crimean war, the late Lord Herbert, in 1858, became chairman of an "Army Sanitary Commission," when the questions of barrack-accommodation, cooking, clothing, and hospital arrangements were inquired into, the information, in detail, being embodied in a tolerably thick blue book of the period.

Returns then obtained showed that for twenty years previously the average rate of mortality in regiments of the Line had been 1·75 per cent., or 17½ per 1,000 of strength; and in the Guards 2·25 per cent., or 22½ per 1,000. In British India the mortality has ranged

from 6·0 to 7·0 per cent., or 60 to 70 per 1,000. Since 1858 improvements of various kinds have been effected both in barracks at home and in India, the results being a very great reduction in the rates of mortality, both at home and abroad. For regiments of the Line, including the Guards, the rate of mortality is now less than 8 per 1,000 per annum, and in British India less than 20 in the 1,000 per annum. If similar care reduces the mortality on the Gold Coast during the Ashantee expedition, we shall, indeed, have so much less of preventable death to mourn over. This saving in death is, however, only part of the gain to the country, as there is a corresponding saving in sickness and in invaliding, in widowhood, in orphanage, and in pensions. *The Times* has had very much to do with this saving of soldier life and human misery. The terrible descriptions of *The Times'* correspondent and almoner in the Crimea, during the suffering and mortality of that fearful winter of 1854-55, drew public attention first, and then forced official attention to the events then progressing; and in certain leaders at that time written, *The Times* stated that so fatal was the sickness then prevailing, and so rapid were the deaths, that it had become a question, not of years, but of months or of weeks, when the last soldier of the British Army in the Crimea would perish. How the feelings of the country were stirred by these details and appeals was shown, practically, by the money subscribed and the articles contributed for the relief of the suffering army. Officialism, after its usual manner, abused *The Times* as an alarmist, and declared that all was going on according to routine, and, therefore, just as it should do. The late Lord Palmerston, then Premier, took, however, *The Times'* view of the question, and sent out Commissions to inquire and act, the results being a rapid diminution both in sickness and in mortality. The great British hospitals on the Bosphorus, which had been allowed to become real pest-houses—they were so ill-ventilated, so over-crowded, and so horribly dirty—were cleansed and put in order, so that by the autumn of 1855 they were almost emptied, as hospital fever was nearly banished. In proof that these amendments in the British Army were due to a better system, and not to altered duties, or change of climate and seasons, there were no such corresponding improvements in the French Army, nor in their hospitals; so that their rate of mortality rather increased than diminished up to the end of the war. Peace with the French had, in fact, become a necessity, as, according to their own returns, some 5,000 men were dying per month in their hospitals—there having been about 15,000 deaths from wounds and fever in the last three months of their Crimean occupation.

In our short Chinese war, under Sir Hope Grant, medical provision was made for the old (or ordinary) rate of sickness and mortality; but, as sanitary arrangements were organised and were attended to, it was said at the end of this war, that the medical provision and hospital arrangements proved to be surplusage and extravagance. Let us hope that this may have to be said at the termination of the Ashantee business, as carried on and completed under the care and wise management of Sir Garnet Wolseley.

TYPHOID FEVER AND HOUSE-DRAINS.

Letter to "The Times," July 31st, 1875.

To the Editor. Sir,—The question of fully ventilating town sewers and house-drains may again be commented upon, so that general attention may be directed to the subject.

Typhoid fever is prevailing "at Mr. Muller's celebrated Orphan Houses, Ashley-down, Bristol;" "the Medical Officer of Health for Bristol to prevent the disease, if possible, being carried into that city, is having the whole of the main drains leading into the north side of the city saturated with sulphate of iron, &c." Disinfectants are also being freely used at the orphan establishment. "Masons are engaged in repairing defective ejects." This is a term I do not understand.

My object in writing this letter is again to direct attention to defective sanitary arrangements in town-sewers and house-drains, and to protest against unventilated public sewers and direct connection of houses by drains with the sewers, as in all such cases sewers and drains are flues in which sewage gas is concentrated and passed to the connected houses, as the inhabitants of the northern side of Bristol will find out by the smell of the disinfectants now being used in the sewers. Towns having steep gradients are more difficult to sewer, safely, than where the fall is not so great. The rules as under are embodied in "Suggestions" published by the Local Government Board, which it is evident the Bristol local authorities do not sufficiently attend to:—

"Main sewers are underground conduits for sewage to flow down, and if they are not fully ventilated at regular intervals along the crown by fixed openings communicating with the external air, they become flues up which sewage gases will rise and pass through the drains to the connected houses.

"Ordinary main sewer ventilation should be provided for in all sewers at intervals not greater than one hundred yards apart.

"The upper, or dead ends, of all sewers and drains should have means provided for full ventilation continued beyond the drain junction of the last house.

"House-drains should not pass direct from sewers to the inside of houses, but all drains should end at an outside wall. House drains, sink-pipes, and soil-pipes should have ample means of external ventilation.

"Where drains must traverse a basement they should be bedded and covered in concrete and have external ventilation back and front.

"Openings direct from drains within the basement should not be allowed, as no form of trap will then be safe."

These rules have been in print some years and have been acted upon in many places; but they have been neglected in many more places, and that neglect may continue. A notice in *The Times* will, however, according to my experience, have more effect than official reports, however widely circulated. There are very few towns in Great Britain where the public sewers are fully ventilated. There are comparatively few houses completely isolated by ventilation from town sewers or from their own drains. There are many houses, old and new, both in town and country, the basement of which are traversed by leaking drains which have cesspits and bell-traps—the one to generate sewage gas, the other to permit of its escape.

The question may be asked—and will, I trust, be asked—by many readers of *The Times*, "What is to be done; who are we to get to remedy the defects?" I can only reply generally. Let members of Town Councils and chairmen of all sanitary authorities consult their local surveyor on these points, asking, "Are our public sewers fully ventilated; are the house-drains severed from the sewers by ventilation?" If the replies are negative or qualified, the orders to have the work well done, and at once, should be positive.

With regard to private houses in the country, my advice is, let each householder who values health ask and examine for himself or herself—the ladies are the best sanitarians—and consult a proper person, and at whatever cost have the needful work done. It will be invidious to name persons who can do such work, as I have no means of knowing the whole. The Lambeth sanitary ware potters, and other sanitary ware-potters, however, make drain-pipes, drain-traps, and drain-trap and closet ventilators, details and prices being in their circulars. There are some recently-devised drain and closet-traps and drain-ventilators which are perfect, if properly used.